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Industrial Safety and Applied Health Physics Division Annual Report for 1981

J. A. Auxier
T. W. Oakes

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ChemRisk Repository Number: 358
Document Number: ORNL 5859
Title: Industrial Safety and Applied Health Physics Division Annual Report for 1981
Authors: J. A. Auxier T. W. Oakes
Abstract: Summarizes activities and data from HP, Environmental Management, and Safety Departments.
Reviewer: T. E. Widner
Document Source or Location: Lab Records
Date Document Issued: 08/00/82
Classification Category: unc
Site Document Addresses: X
Primary Document Category: HO
Secondary Document Category: ED
Date Entered: 11/25/92
Entered By: kah
Keywords: Annual Summary

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A06 Microfiche A01

ORNL-5859
Dist. Category UC-41

Contract No. W-7405-eng-26

INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS DIVISION ANNUAL REPORT FOR 1981

J. A. Auxier, Director

T. W. Oakes, Coordinator

Date Published: August 1982

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

Acknowledgements

The authors would like to acknowledge the IS&AHP staff members who performed the actual tasks of collecting data and performing analyses and the secretaries who typed the results. We would also like to thank the staff members of the Technical Publications Department, especially Lydia Corrill and AnnaJo Shelton, for their time, patience, and technical assistance in compiling this report.

Contents

1. Introduction

The Industrial Safety and Applied Health Physics (IS&AHP) Division has been guided in the past by its dedication to the protection of humans and the environment from the deleterious effects of ionizing and nonionizing radiation. The staff has attempted to achieve this without stifling the development of the beneficial aspects of nuclear energy. They have concentrated on protecting the ORNL worker and the environment surrounding the Laboratory.

The radiation protection program provides for the measurement, assessment, and control of radiation and contamination hazards so that exposure to personnel in the workplace will be kept as low as reasonably achievable (ALARA). To meet this objective, the Health Physics Department conducts radiation and safety surveys; provides personnel monitoring services for both external and internal radiation; and procures, services, and calibrates appropriate portable and stationary health physics instruments.

The specific goals of the environmental program are (1) to determine quantities of radionuclides and other hazardous material discharged to surface water and groundwater from buried waste and other sources at ORNL, (2) to find ways of reducing these discharges, and (3) to establish improved sampling and monitoring methods. Waste-management practices developed in this program will be evaluated for potential use in other energy technologies, including the combustion and conversion of coal. New legislation and an intensified awareness of environmental issues have greatly increased the requirements for monitoring, controlling, and reporting of nonradioactive pollutants. Members of the Department of Environmental Management play a vital role in meeting all these requirements.

The division has also been instrumental in ensuring a high level of safety in all ORNL operations. The lack of any major operational accidents and continued receipt of the highest safety awards affirm the effectiveness of the various activities developed by the Safety Department to support the ORNL safety program.

The last few years have seen significant changes at ORNL: a Laboratory that was once almost wholly dedicated to work on nuclear projects now includes a large proportion of nonnuclear technologies. At the same time, the basic sciences supporting these technologies have shifted emphases from nuclear to nonnuclear studies.

The main growth that has taken place at the Laboratory has been in the technological sections, but it has been accompanied by shifts in emphasis within the science sections. These changes necessitate that the IS&AHP Division, as a service division, respond to the needs of these new programs.

Thus, in looking to the future, division staff members must dedicate themselves to the protection of humans and the environment from the harmful effects of any energy technology. We will attempt to achieve this task while allowing maximum economic, social, and health benefits from the development and use of new energy systems.

2. Summary

2.1 HEALTH PHYSICS DEPARTMENT

- The maximum whole-body dose sustained by an employee was about 3.8 rems (38 mSv), which is 76% of the applicable standard of 5 rems (50 mSv).
- The greatest cumulative whole-body dose received by an employee was about 115 rems (1.15 Sv). This was accrued over an employment period of about 38 years and represents an average of about 3.0 rems/year (30 mSv).
- The greatest cumulative dose to the skin of the whole body received by an employee during 1981 was about 5.9 rems (59 mSv), or 39% of the applicable standard of 15 rems (150 mSv).
- The maximum cumulative hand dose recorded during the year was about 15 rems (150 mSv), or 20% of the applicable standard of 75 rems (750 mSv).
- During the year, no cases of internal exposure occurred for which the amount of radioactive material within the body averaged as much as one-half the maximum permissible organ burden for the year.
- About 590 whole-body, chest, wound, thyroid, and liver counts were performed at the Whole Body Counter Facility during the year.
- Small quantitities of various fission or activation products were identified in a few individuals, but no one was found to have an internal deposition greater than 10% of the maximum permissible organ burden of that isotope for the year.
- In 1981, the ORNL Whole Body Counter Facility staff completed development of the 80-cm^2 solid-state (hyperpure germanium) array for in vivo detection of low-energy photon and x-ray emitters.
- Initial experimentation has been completed on a CaF_2(Eu)-NaI(Tl) phoswich for alpha-beta-gamma spectroscopy of environmental samples.
- A computer program named INTDOS has been written to allow user-oriented calculation of dosimetric quantities used in estimating integral committed doses from in vivo measurements.
- Continuous monitoring was provided during the removal of radioactive liquid waste from an abandoned ILW transfer line that was previously used to transfer waste from the tank farm in the hydrofracturing facility. No spread of contamination occurred, and personnel exposures were well below permissible levels.
- Eighty x-ray units are located at ORNL: 44 x-ray diffraction units, 12 small cabinet x-ray systems, 10 walk-in-type total-enclosure units, 6 fluoroscopy units, 3 radiographic units in hot cells, 3 portable radiographic units, 1 particle-size analyzer, and 1 medical x-ray unit.

- An inspection and radiation survey was performed on each of these units during the past year to ensure that they were in compliance with all applicable regulations, American National Standard N43.2, and ORNL Health Physics Procedure 2.8.

- Ninety-two microwave cooking ovens at the Laboratory were checked for microwave leakage and interlock integrity. Leakage on all ovens was within federal limits, and no interlock failures were found. A study is under way to identify all radio-frequency-generating devices to assess the need for a broadband detection instrument.

- About 520,000 articles of wearing apparel and 184,000 articles such as mops, laundry bags, and towels were monitored at the laundry during 1981; about 5.8% were found to be contaminated. Of 319,765 khaki garments monitored during the year, only 44 were found to be contaminated.

- Two members of the IS&AHP Division assisted in the evaluation of alpha contamination levels at the HFIR Fuel Element Fabrication Facility operated by Texas Instruments Company in Attleboro, Massachusetts.

2.2 DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

- Atmospheric iodine sampled at the perimeter stations averaged 0.13E−14 μCi/cc (0.47E−4 Bq/m^3) during 1981. This average represents <0.005% of the concentration guide of 1E−10 μCi/cc (3.7 Bq/m^3) applicable to inhalation of ^{131}I released to uncontrolled areas. The maximum concentration observed for one week was 0.32E−14 μCi/cc (0.12E−3 Bq/m^3).

- All air samples taken had values below the allowable standards.

- If the average intake of milk per individual is assumed to be 1 L/d, the concentrations of ^{131}I in milk collected near ORNL and from all remotely located stations are within Federal Radiation Council (FRC) range I.

- The concentrations of ^{90}Sr in milk from both the immediate and remote environs of ORNL are also within FRC range I.

- The average value of 1.5E−9 μCi/mL (0.56E−1 Bq/L) represents 0.5% of the CG_w for drinking water applicable to individuals in the general population.

- The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the banks of the Clinch River adjacent to a cesium field experimental plot and results primarily from sky shine from the plot. A maximum potential whole-body dose of 215 mrem/year (2.2 mSv/year) was calculated for this location, assuming that an individual remained at this point for 24 h/d for the entire year. The calculated maximum potential exposure is 43% of the allowable standard.

- The Analytical Chemistry Division and ten of its staff members were named recipients of the first Environmental Protection Awards.

- During 1981, the ORNL Meteorological Committee continued to play an important role in the development of a meteorological tower system for ORNL.

- During 1981, about 420 disposal requests were handled by the Hazardous Materials Management Group of the Department of Environmental Management (DEM).

- During 1981, DEM coordinated the stack compliance test for ORNL's Steam Plant. The plant met all appropriate state and EPA standards and is currently in routine operation.
- Environmental assessments for 29 projects were completed in 1981.
- Work was completed on a storage facility for spent photographic processing solutions and on improvements in the waste-oil storage area.
- The NUS Corporation prepared the *ORNL Environmental and Safety Report*.
- Effective February 1, 1981, DEM assumed responsibility for the environmental protection of ORNL facilities at Y-12, and at that time a field office was established in Building 9200 to coordinate activities.

2.3 SAFETY DEPARTMENT

	Lost-work-day cases		Recordable injuries and illnesses	
	Number	Incidence rate	Number	Incidence rate
1981 (actual)	0	0.00	41	0.95
1981 (goal)	2	0.04	45	1.00

- Through December 31, 1981, the Laboratory had accumulated 600 days (14,015,826 exposure-hours) without a lost-work-day case.

	Off-the-job disabling injuries	Off-the-job frequency rate
1981 (actual)	60	3.29
1981 (goal)	68	3.53

- The Laboratory earned the following awards for safety performance in 1981:

1. UCC Silver Award for Outstanding Safety Performance for operating 12,000,000 employee-hours without a lost-work-day case from May 11, 1980, through October 6, 1981.
2. UCC Bronze Award for Outstanding Safety Performance for operating 8,000,000 employee-hours without a lost-work-day case from May 11, 1980, through April 13, 1981.
3. National Safety Council Award of Honor for the seventh consecutive year (NSC's highest award). For 1981, ORNL also had the best record among research and development laboratories, according to NSC.
4. First Place in the National Safety Council's Chemical Section Safety Contest, Group 1.
5. DOE Award of Achievement for maintaining the incidence rate of lost work days and restricted work cases below 1.0 for four consecutive years.
6. DOE-ORO Outstanding Safety Performance Award for operating through CY 1981 without a case involving days away from work.

- Ten ORNL divisions did not have a recordable injury or illness (RII) in 1981.

- During 1981, safety analysis documentation continued on the 7920 Transuranium Processing Plant (TRU), 3019 Pilot Plant, 3100 Vault, a site-generic document, Solid Waste Storage Facility, 7025 Tritium Target Facility, and 5505 Transuranium Research Laboratory (TRL).

- In addition, five other existing facilities were added to the documentation schedule for FY 1981. These facilities were the 86-in. Cyclotron; the Alpha Labs, Room 136, Building 4508; the High Level Analytical Laboratory, Building 2026; the Alpha Isolation Lab, Building 3508; and the Radiation Gas Handling Building, 3033W.

- No facility or nuclear reactor accidents or incidents of an operational nature that resulted in injury to personnel or that were reportable to DOE other than as unusual occurrence or quality deficiency reports occurred in 1981.

3. Health Physics Department

3.1 RADIATION MONITORING

3.1.1 Personnel Monitoring

All persons who enter Laboratory areas where they are likely to be exposed to radiation or radioactive materials are monitored for the probable kinds of exposure. External radiation dosimetry is accomplished mainly by means of badge-meters, pocket ion chambers, and hand exposure meters. Internal deposition is determined from bioassays and in vivo counting.

Dose analysis summary

External exposures. In 1981, no employee received a whole-body radiation dose that exceeded the standards for radiation protection given in DOE Order 5480.1.[1] The maximum whole-body dose sustained by an employee was about 3.8 rems (38 mSv), or 76% of the applicable standard of 5 rems (50 mSv). The range of doses to persons using ORNL badge-meters is shown in Table 3.1.

At the end of 1981, no employee had a cumulative whole-body dose greater than the applicable standard based on the age proration formula $5(N - 18)$ (Table 3.2). No employee had an average annual dose that exceeds 5 rems/year (50 mSv) of employment (Table 3.3). The greatest cumulative whole-body dose received by an employee was about 115 rems (1.15 Sv). This was accrued over an employment period of about 38 years and represents an average of about 3.0 rems (30 mSv)/year.

The greatest cumulative dose to the skin of the whole body received by an employee during 1981 was about 5.9 rems (59 mSv), or 39% of the applicable standard of 15 rems (150 mSv). The maximum cumulative hand dose recorded during the year was about 15 rems (150 mSv), or 20% of the applicable

Table 3.1. 1981 dose data summary for monitored personnel involving exposure to whole-body radiation

Group	Dose range [rems (mSv)]							Total
	0–0.1 (0–1)	0.1–1 (1–10)	1–2 (10–20)	2–3 (20–30)	3–4 (30–40)	4–5 (40–50)	5 up (50 up)	
ORNL employees	62	268	39	5	1	0	0	375
ORNL-monitored nonemployees	498	13	1	0	0	0	0	512
Total	560	281	40	5	1	0	0	887

1. DOE Order 5480.1, Chap. XI.

Table 3.2. 1981 average dose per year since age 18

Group	Dose range [rems (mSv)] 0–1 (0–10)	1–2 (10–20)	2–3 (20–30)	3–4 (30–40)	4–5 (40–50)	5 up (50 up)	Total
ORNL employees	342	27	6	0	0	0	375

Table 3.3. 1981 average dose per year of employment at ORNL

Group	Dose range [rems (mSv)] 0–1 (0–10)	1–2 (10–20)	2–3 (20–30)	3–4 (30–40)	4–5 (40–50)	5 up (50 up)	Total
ORNL employees	295	73	5	2	0	0	375

standard of 75 rems (750 mSv). The average of the ten greatest whole-body doses to ORNL employees for each of the years 1977 through 1981 is shown in Table 3.4.

Internal exposures. During the year no cases of internal exposure occurred for which the amount of radioactive material within the body averaged as much as one-half the maximum permissible organ burden for the year.

Table 3.4. Average of ten highest whole-body doses and highest individual dose by year

Year	Ten highest doses (average) rem	Ten highest doses (average) mSv	Highest dose rem	Highest dose mSv
1977	2.84	28.4	3.62	36.2
1978	2.39	23.9	3.34	33.4
1979	2.24	22.4	2.80	28.0
1980	2.46	24.6	3.14	31.4
1981	2.20	22.0	3.83	38.3

External dose techniques

Thermoluminescent dosimeters. Standard thermoluminescent dosimeters (TLDs) are issued to all employees and to photobadged nonemployees who work in radiation zones. Standard TLD meters have two TLD chips, one shielded and one unshielded. Specialized meters with various complements of TLDs and films are issued to those who may be exposed to other than gamma and energetic beta radiation.

TLD meters of radiation workers are exchanged and processed quarterly, or more frequently if required for exposure control. All other meters are exchanged and processed annually.

Pocket meters. Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL. A pair of pocket meters is carried for the duration of a work shift by persons who work in areas where the potential exists for a dose of 20 mrad (0.2 mGy) or more during the work shift. Pocket meter pairs are processed each day by health physics technicians. Readings of 20 mrad (0.2 mGy) or more are reported to supervision daily. Over 150,000 pocket ionization chambers were used and processed during 1981. Printouts giving all readings, along with weekly totals and cumulative totals, are sent to supervision weekly. Pocket meter readings are used for estimating integrated exposure and as a basis for TLD meter processing during a TLD meter assignment period.

Hand exposure meters. Hand exposure meters are TLD-loaded finger rings. Hand exposure meters are issued to persons for use during operations in which the hand dose is likely to exceed 1 rem (10 mSv) during the week. They are issued and collected by Radiation and Safety Surveys (R&SS) Section personnel, who determine the need for this type of monitoring and arrange for a processing schedule. A summary of personnel meters services is presented in Table 3.5.

Table 3.5. Personnel meters services

	1979	1980	1981
Pocket meter usage			
Number of pairs used			
ORNL	70,238	69,410	69,722
CPAF[a]	8,022	5,026	6,384
Total	78,260	74,436	76,106
Average number of users per quarter			
ORNL	679	671	673
CPAF[a]	174	109	133
Total	853	780	806
Meters processed for monitoring data			
Beta-gamma badge-meter	30,520	15,260	3,548
Neutron badge-meter	800	1,030	1,159
Hand meter	720	460	285

[a]Cost plus award-fee contractor (Rust Engineering).

Internal dose techniques

Bioassay. Urine and fecal samples are analyzed to determine amounts of internal intake. The frequency of sampling and the type of radiochemical analysis performed are based on each specific radioisotope and the intake potential.

In most cases, bioassay data require interpretation to determine the dose to the person; computer programs are used to evaluate extensive data on urinary excretion of ^{239}Pu. An estimate of dose is made for all cases in which one-fourth of a maximum permissible organ burden averaged over a calendar year may be exceeded. The analyses performed by the Industrial Safety and Applied Health Physics (IS&AHP) radiochemical laboratory during 1981 are summarized in Table 3.6.

Table 3.6. Radiochemical laboratory analyses, 1981

Radionuclide	Urine	Feces	Milk	Water	Controls
Plutonium, α	330	2		52	78
Transplutonium, α	315	2		52	78
Uranium, α	193				78
Strontium, β	172		420		50
Tritium	136			104	50
^{131}I			420		52
Other	19				10
Total	1185	4	840	208	396

Whole-body counter. The whole-body counter (an in vivo gamma spectrometer) is used in estimating internally deposited quantities of most radionuclides that emit photons.

About 590 whole body, chest, wound, thyroid, and liver counts were performed at the Whole Body Counter Facility during the year. Most of the subjects counted had ^{137}Cs in the range of 1–13.5 nCi (37–500 Bq), from fallout from nuclear weapons testing. Small quantities of various fission or activation products were identified in a few individuals, but no one was found to have an internal deposition greater than 10% of the maximum permissible organ burden of that isotope for the year.

Counting facility. The counting facility determines the radioactivity content of air-filter, water, and various other samples submitted by the IS&AHP sections. A summary of the analyses is given in Table 3.7.

Table 3.7. Counting facility analyses, 1981

Type of sample	Number of samples		Unit total
	α	β	
Facility monitoring			
Smears	16,239	16,903	33,142
Air filters	14,757	14,316	29,073
Environs monitoring			
Air filters	3,064	3,064	6,128
Fallout		2,958	2,958
Rainwater		769	769
Surface water		289	289

Reports

Routine reports of personnel monitoring data are prepared and distributed to divisional supervision and to the IS&AHP staff.

Pocket meter data. A report is prepared and distributed daily to supervision of the names, ORNL divisions, and readings for pocket meters that were 20 mrad (0.2 mGy) or greater during the previous 24 h.

A computer-prepared report that includes all pocket meter data for the previous week and summary data for the calendar quarter is published and distributed weekly.

External dosimetry data. A computer-prepared report that includes data of recorded skin dose and whole-body dose for the previous calendar quarter and totals for the current year is published quarterly. ORNL divisions receive a computer-prepared report that is an annual summary of the quarterly reports.

Bioassay data. A computer-prepared report that includes data of sample status and results for the previous week is published and distributed weekly, and quarterly and annual reports of results are also prepared and distributed.

Whole-body counter data. Preliminary results of an analysis are reported on a card form soon after counting is completed. A computer-prepared report is published and distributed quarterly and annually.

Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photobadge.

3.1.2 Health Physics Instrumentation

The IS&AHP Division shares with the Instrumentation and Controls (I&C) Division the responsibility of selecting electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the IS&AHP Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics design requirements, and for approving the design. The IS&AHP Division is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the I&C Division.

Nonelectronic personnel monitoring devices are designed, tested, calibrated, and maintained by IS&AHP personnel.

Instrument inventory

The electronic instruments used in the health physics program are divided, for convenience of servicing and calibrating, into two classes: (1) battery-powered portable instruments and (2) stationary instruments that are ac powered. Portable instruments are assigned and issued to the R&SS complexes. Stationary instruments are the property of the ORNL division responsible for monitoring the areas in which the instruments are located. Table 3.8 lists portable instruments assigned at the end of 1981, and Table 3.9 lists stationary instruments in use at the end of 1981.

Table 3.8. Portable instrument inventory, 1981

Instrument type	Installed	Retired	Total (Jan. 1, 1982)
GM survey meter	5	0	316
Cutie pie	7	13	304
Alpha survey meter	6	1	254
Neutron survey meter	1	0	102
Miscellaneous	2	2	9
Total	21	16	985

Table 3.9. Inventory of facility radiation monitoring instruments, 1981

Instrument type	Installed	Retired	Total (Jan. 1, 1982)
Air monitor, α	0	0	110
Air monitor, β	0	1	160
Lab monitor, α	0	0	184
Lab monitor, β	1	0	229
Monitron	1	0	204
Other	2	4	144
Total	4	5	1031

Inventory and service summaries for health physics instruments are prepared by computer. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements. The allocation of stationary health physics monitoring instruments by division is shown in Table 3.10.

Table 3.10. Divisional allocation of health physics facility monitoring instruments, 1981

ORNL division	α air monitor	β air monitor	α lab monitor	β lab monitor	Monitron	Other	Total
Analytical Chemistry	8	12	16	20	12	3	71
Chemical Technology	44	32	67	47	45	31	266
Chemistry	7	2	13	14	0	2	38
Metals and Ceramics	15	15	22	12	8	17	89
Operations	24	87	50	91	111	51	414
Physics	2	2	4	15	3	4	30
Others	10	10	12	30	25	36	123
Total	110	160	184	229	204	144	1031

Calibration facility

The IS&AHP Division maintains a facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote-control devices, and shop space for use by I&C Division maintenance personnel. IS&AHP personnel assign, calibrate, arrange for maintenance of, provide for delivery of, and maintain inventory and servicing data on all portable health physics instruments.

Radiation sources used for calibration have been either standardized by the National Bureau of Standards (NBS) or evaluated by comparison with sources standardized by the bureau.

The recommended maintenance and calibration frequency is two (no more than three) months for instruments that measure exposure, absorbed dose, or dose equivalent rates (cutie pie, Juno, and fast-neutron survey meter) and three (no more than four) months for count-rate instruments [gas flow, scintillation, Geiger-Mueller survey meter (GMSM), thermal neutron, and air proportional]. Table 3.11 shows the number of calibrations of portable instruments and personnel monitoring devices for 1981.

Table 3.11. Calibrations facility resume, 1981

Item	Number of calibrations
Beta-gamma survey meters	2086
Neutron survey meters	294
Alpha survey meters	770
Personal dosimeters	3240
Badge dosimetry components	1580

3.1.3 Developments

Hyperpure germanium array for lung counting

In 1981 the ORNL Whole Body Counter Facility staff completed development of the 80-cm^2 solid-state (hyperpure germanium) array for in vivo detection of low-energy photon and x-ray emitters. Computer programs for analysis of lung burdens of ^{239}Pu and ^{241}Am and the prediction of background continuums were written and implemented based on data acquired from uncontaminated male and female subjects. A library was compiled for some of the most commonly occurring radionuclides and was incorporated into computer programs for rapid identification and quantification of these radionuclides. A computer program to estimate the thickness of the chest wall based on various body measurements was implemented into the standard procedure.

Calcium fluoride–sodium iodide phoswich for sample analysis

Initial experimentation has been completed on a CaF_2(EU)-NaI(Tl) phoswich for alpha-beta-gamma spectroscopy of environmental samples. This phoswich system appears to afford a reduction in the minimum detectable activity by a factor of $\sim$10 for ^{239}Pu in 20-g samples of soil, which also contain mixed fission products, over existing detector systems (e.g., FIDLER and ZnS detectors). The system has not yet been field tested, but it is anticipated that results will be favorable.

Sample counting standards

All calibration sources for the counting facility were restandardized by comparison with sources standardized by the NBS.

Bioassay standards

Solutions containing radioactivity that are used for tracers and control standards for bioassays were restandardized by comparison with solutions standardized by the NBS, if available, or by other means if not.

Collection and determination of very low levels of actinide elements by anion exchange

A method has been developed for the adsorption and recovery of the entire actinide series by anion exchange. The method, which was designed for body fluid and low-level environmental samples, consists of a basic phosphate precipitation, dissolution of the precipitate, pH adjustment, and ion exchange adsorption and elution. The metaphosphate complexes of the actinides are readily adsorbed on chloride anion resins, at phosphate concentrations of about 0.005 *M*. These elements may be eluted from the resin as a unit and the various nuclides quantified by alpha spectrometry. Also, the trivalent actinides may be eluted as a unit and the remaining actinides eluted sequentially.

Internal dosimetry methods

A computer program named INTDOS has been written to allow user-oriented calculation of dosimetric quantities used in estimating integral committed doses from in vivo measurements. These calculational methods are based on the latest recommendation of the International Commission on Radiological Protection (ICRP) as provided in ICRP publications 26 and 30.

Indium foil calibration for use in evaluating criticality exposures

The UCC-ND badge contains an indium foil intended for use as a screening device for personnel exposed in criticality accidents. A convenient and quick method of categorizing exposures based on indium foil readings with a GMSM and postexposure time was developed. With this method, personnel exposed at <5, 5–25, and >25 rems can be separated into three groups so that personnel with higher exposures can be given priority with respect to dosimetry and medical attention.

Radon-immune air monitor for plutonium

The gross alpha activity in particulate-associated daughters of radon in the work environment may be many times that of the maximum permissible concentration in air (MPC_a) of ^{239}Pu or ^{238}Pu. The daughters of radon emit both alpha and beta particles, and the ratio of alpha to beta activity is variable and a function of several factors. Despite this variability, the ratio changes slowly with time and has upper and lower bounds in buildings that have controlled ventilation. These characteristics provided the basis for the development of an air monitor in which radon interference is virtually eliminated.

The radon-immune air monitor has three detectors: one observes alpha activity on the filter, one observes beta activity on the filter, plus gamma background, and one observes gamma background. Counts from these detectors are fed into a microprocessor programmed with an algorithm for computing the non-radon-associated alpha activity.

3.2 RADIATION AND SAFETY SURVEYS

3.2.1 Laboratory Operations Monitoring

The Radiation and Safety Surveys (R&SS) Section provided radiation surveillance services to the research and operating groups in support of efforts to keep exposures to personnel, concentrations of airborne radioactivity, and levels of surface contamination well within permissible limits, as well as in agreement with the as-low-as-reasonably-achievable (ALARA) philosophy. Assistance in coping with the problems associated with radiation work was provided through seminars, safety meetings, and discussions with those planning, supervising, and performing the work. The following is a brief review of some of the major activities involving R&SS staff.

Bulk Shielding Reactor, Building 3010

During 1981 the last of a series of capsule irradiations for the Heavy Section Steel Technology (HSST) program was conducted. This experiment was a continuation of earlier experiments conducted at the BSR to determine how long reactor vessels could remain reliable and safe for operation and to enhance further the nuclear industry's knowledge of reactor safety.

The BSR was also used by several research divisions at ORNL for short-term irradiations of various samples. These samples were inserted and removed from the core. Health physics surveillance indicated a minimum of radiation exposure to personnel involved in these operations.

Radiochemical Pilot Plant Operations, Building 3019

During the year, 181 Radiation Work Permits were issued for operations involving significant radiation hazard potential. These operations included the decommissioning of one facility and the decontamination and replacement of several major equipment items in a process cell. In general, good control of personnel exposures and radioactive materials was achieved.

Decommissioning of the Solex Development Laboratory (room 303A), started in 1980, was completed this year. The process equipment was contained in two large gloved boxes. Solutions were removed from the equipment, miscellaneous services (except off-gas) were discontinued, and process connections were severed and capped outside the boxes. The boxes were then filled with urethane foam to stabilize the equipment and to fix residual gross alpha contamination. A steel shell, fabricated around each gloved box, provided containment during transfer to and consignment in the solid waste disposal area.

The "Scrap" Dissolver (S-20) and the Extraction Column (N-1) were removed from the ^{233}U Process System in cell 5 in preparation for replacement with new units. After internal decontamination, S-20 and N-1 were disconnected from the process and all pipe stubs were capped. Personnel, wearing air-supplied plastic suits, sprayed the external surfaces of the equipment with hot solutions of trisodium phosphate, oxalic acid, sodium fluoride, and hydrogen peroxide to remove gross alpha contamination. Residual surface contamination was fixed by application of paint and vinyl tape. The lower section of N-1 was inserted into a metal culvert, which was then filled with urethane foam. The various pieces of equipment were then transferred to the solid waste disposal area in a reusable wooden box. These procedures were very effective in preventing contamination of personnel and the release of radioactive contaminants.

Site preparation for the Consolidated Edison Uranium Solidification Program (CEUSP) continued. Sections of the stainless liner, drain lines, process pipes, and other protrusions into cell 3 were removed to provide adequate clearance for CEUSP enclosures. The CEUSP off-gas ducts in cell 4 and the air supply system to the control room (506) were installed. Hundreds of anchor-bolt holes were drilled into the wall and ceiling surfaces of cell 3. All these jobs involved a potential for release of fixed, bonded, or contained radioactive contamination from operations in years past. Execution of confinement techniques proved adequate for preventing contamination of personnel and for confining contaminant release into the immediate area.

Isotope Area Operations, Building 3038

Work at this location consisted of the production, packaging, and shipping of radioisotopes for medical, industrial, and experimental uses. Principal isotopes were ^{3}H, ^{67}Ga, ^{75}Se, ^{85}K, ^{90}Sr, ^{137}Cs,

^{153}Gd, ^{192}Ir, ^{237}Np, ^{241}Am, and several isotopes of Pu. The Isotope Research Materials Laboratory continued the fabrication of flux foils from various isotopes of U, Np, Th, and Pu. This group also completed the fabrication of ^{241}Am and ^{244}Cm pellets to be loaded in fuel pins that were used in a joint United States–United Kingdom Higher Actinide Experiment. The amount of ^{244}Cm used created an exposure problem, but close surveillance kept exposures within acceptable limits.

Decontamination of curium cells in Building 3028 was begun. Readings inside cell 3 were 500 mrad/h (5 mGy/h), but the extremely high transferrable contamination constituted the main problem. Plastic suits worn in the cells had to be cut off to avoid contaminating the operator. Decontamination efforts are continuing in the area behind the cells. Exposures to personnel have been very low, and the spread of contamination has been controlled. Cell D in Building 3047 was surveyed before extensive decontamination of the cell was begun, and readings ranged from 3 rad/h (30 mGy/h) at the doorway to 100 rad/h (~1 Gy/h) inside the cell. Although the readings were very high, close monitoring by health physics personnel succeeded in keeping individual dose equivalents within permissible limits.

Oak Ridge Research Reactor, Building 3042

During 1981 several experiments were inserted and removed from the ORR reactor vessel with the assistance of R&SS personnel. One such experiment conducted during this period was a continuation of a series of experiments designed to study the fast-neutron-induced creep of graphite. The main objectives of the experiments were to determine primary and secondary creep coefficients and other property data required for the constitutive equations for graphites used in high-temperature reactors. Much of the work related to the insertion and removal of these experiments was accomplished after the water was lowered to the top of the reactor vessel. Radiation exposures to personnel were kept to a minimum, and contamination was confined to the established zoned areas.

Metal Recovery, Building 3505

R&SS personnel provided surveillance and assistance for Evaluation Research Corporation (ERC) and Rust Engineering (Rust) in the radiological survey of the Metal Recovery Building. ERC performed the radiological survey of the facility to provide data related to decontamination and decommissioning of the facility, while Rust provided the personnel to operate the core-drilling equipment for the soil samples around the building grounds. Personnel exposure controls were effective and contamination controls were adequate.

Fission Development Laboratory, Building 3517

Extensive decontamination was performed in cells 10 and 11 to reduce background before modification and repair to the cells began. After decontamination and addition of shielding to areas that were accessible, the background ranged from 1–2 rad/h (10–20 mGy/h), with spots as high as 10 rad/h (0.1 Gy/h) at 15 cm in cell 11. Readings in cell 10 ranged from 200–500 mrad/h (2–5 mGy/h). It was necessary to add 1 mrem (10 μSv) for each minute an employee worked in cell 10 to allow for neutron exposure from the ^{244}Cm stored there. Modifications to cell 11 consisted of filling the deep well with concrete; installing two manipulator ports, a new manipulator window, and a new lighting system; and other refurbishing. Cell 10 modification consisted of replacing a broken manipulator window. With careful planning and continuous surveillance by R&SS personnel, exposure controls were effective and contamination was confined.

High Voltage Laboratory, Building 5500

Special handling and monitoring procedures were developed to minimize exposure of Metals and Ceramics Division personnel who examined radiation damage to point-source stainless samples irradiated at the High Flux Isotope Reactor (HFIR).

Transuranium Research Laboratory, Building 5505

The IS&AHP staff at the Transuranium Research Laboratory (TRL) continued to provide protective technical support to experimental programs involving the investigation of physical and chemical properties of transuranic elements. This support included working directly with researchers in the designing of appropriate containment enclosures and procedures, the assembling and disassembling of apparatus, the conducting of various experiments, and the decontaminating and disposing of radioactive wastes. In addition, the staff continued to function as building operators in charge of all aspects of the TRL ventilation and containment system. Also, two members of the staff assigned to this facility functioned as the Chemistry Division's Radiation Control and Division Safety Officer (RCO/DSO) and alternate and participated in the preparation and writing of a revised safety analysis for the facility.

Oak Ridge Isochronous Cyclotron, Building 6000

IS&AHP Division staff provided assistance in stabilizing conditions immediately following the flooding accident in the Oak Ridge Isochronous Cyclotron (ORIC), University Isotope Separator Oak Ridge (UNISOR), and Holifield Heavy-Ion Facility areas. Radioactive contamination was located and contained, which simplified the cleanup process. By preventing the spread of contamination, conventional cleanup methods could be used.

Oak Ridge Electron Linear Accelerator, Building 6010

The relocated Magnetic Fusion Energy Deuteron Accelerator was assembled, upgraded, and checked. Radiation surveillance was provided for the purpose of monitoring radiation levels both inside and outside the building during the testing phase. Internal dose was also followed closely because ^{3}H contamination was present on accelerator component parts.

Nuclear Safety Pilot Plant Operations, Building 7500

Experiments in which uranium metal was burned in a containment vessel to simulate fuel aerosol particles that might be generated in an accident involving the fuel in light-water reactors (LWR) were continued. Samples of iron and concrete were vaporized and injected into the vessel to simulate molten reactor fuel contacting surrounding steel and concrete components. During this operation, live steam was also injected to simulate the primary coolant. Health physics assistance and surveillance were provided during these experiments, all of which were performed without incident.

Dosimetry Applications Research Facility, Buildings 7709 and 7710

Surveillance services and technological assistance were provided for a number of research programs. These included activation of indium criticality detector strips for use in a simulated radiation incident and tests on criticality detector systems for all the main plants in the Nuclear Division. A radiation biology study in which mice were injected with various radioprotective drugs before being irradiated was continued. The two dosimetry comparison studies involving personnel and nuclear accidents were conducted again this year. Both studies involved people from the United States and foreign countries.

High Flux Isotope Reactor, Building 7900

During 1981 HFIR was shut down 16 times to replace fuels, target rods, and experiments. Shutdowns were also utilized to repair radioactive pumps and valves, replace control-plate drive rods and rod seals, and inspect or replace reactor components. Three of the primary heat exchangers were repaired during the year.

Close surveillance was also provided during routine reactor operations, such as removal and shipment of intensely radioactive isotope rods and the loading and transfer of spent fuel elements. Over $\sim 10^6$ Ci (10^{16} Bq) of iridium alone was irradiated and shipped in 1981.

Transuranium Processing Activities, Building 7920

Continued application of the ALARA concept was carried out with the installation of two additional neutron and gamma shields on gloved boxes for reduction of dose equivalents to personnel working routinely at these boxes. Further improvements were made in waste-handling techniques to reduce exposure to personnel.

Close surveillance and assistance were provided for routine operations, as well as for some new operations. The latter included chemical development work on microsphere formation, using internal gelation techniques, and a Solvent Extraction Test Facility to provide a flowsheet for the solvent extraction of actinides.

Tank Farm Operations

Close surveillance was provided for cost-plus-award-fee contractor (Rust) personnel as work continued on the Gunite Tank Sludge Removal Project. Contamination and radiation were encountered during excavation work and equipment installation. However, contamination control was adequate, and personnel exposures were kept well below maximum permissible levels.

Removal of Intermediate-Level-Waste Transfer Line

Continuous monitoring was provided during the removal of radioactive liquid waste from an abandoned ILW transfer line that was previously used to transfer waste from the tank farm to the hydrofracturing facility. No spread of contamination occurred, and personnel exposures were well below permissible levels. In conjunction with the decontamination and decommissioning program, plans are now under way for removing and disposing of the pipeline.

3.2.2 X-Ray and Microwave Surveys

X-Ray Program

Eighty x-ray units are located at ORNL: 44 x-ray diffraction units, 12 small cabinet x-ray systems, 10 walk-in-type total-enclosure units, 6 fluoroscopy units, 3 radiographic units in hot cells, 3 portable radiographic units, 1 particle-size analyzer, and 1 medical x-ray unit.

An inspection and radiation survey was performed on each of these units during the past year to ensure that they were in compliance with all applicable regulations, American National Standard N43.2, and ORNL Health Physics Procedure 2.8.

The most commonly found problems were the absence of operating procedures and lists of authorized users, the absence of signs to indicate potential hazards, and deficient security of control consoles. These deficiencies were corrected; current registration forms, indicating radiation levels and operating restrictions, if any exist, are posted at each machine.

Microwave Program

Ninety-two microwave cooking ovens at the Laboratory were checked for microwave leakage and interlock integrity. Leakage on all ovens was within federal limits, and no interlock failures were found. A study is under way to identify all radio-frequency-generating devices to assess the need for a broadband detection instrument.

3.2.3 Laundry Monitoring Operations, Building 2523

About 520,000 articles of wearing apparel and 184,000 articles such as mops, laundry bags, and towels were monitored at the laundry during 1981; about 5.8% were found to be contaminated. Of 319,765 khaki garments monitored during the year, only 44 were found to be contaminated.

During the year, 5588 full-face respirators and 9837 canisters were monitored. Of these, 199 masks and 384 canisters required further decontamination after the first cleaning cycle.

3.2.4 Offsite Surveillance

Runway Light Tests

A member of the R&SS Section provided assistance to the Operations Division during offsite demonstrations of distance-marking runway lights made of ^{3}H and ^{85}Kr. The demonstrations took place at Bogue Auxiliary Field, North Carolina, and at Andrews Air Force Base, Maryland.

Exposure of personnel who assisted in assembling and disassembling the light units, setting them up in their various configurations, and loading and unloading them was closely monitored. Personnel were also prevented from remaining in the proximity of the lights when their work was completed, and interested onlookers were kept at a safe distance.

HFIR Fuel Element Manufacturing Facility

Two members of the IS&AHP Division assisted in the evaluation of alpha contamination levels at the HFIR Fuel Element Fabrication Facility operated by Texas Instruments Company in Attleboro, Massachusetts. The welding room, fuel manufacturing area, press room, weighing room, and vault were surveyed. The data obtained were used by the Operations Division in determining the disposition of equipment and status of the facility.

Servicing of Threshold Detector Units

The Lexan discs used to record tracks in the threshold detector units at the Reactive Metals, Inc. (RMI), plant in Ashtabula, Ohio, were replaced on site by a member of the R&SS staff. Only those discs placed next to the plutonium foils were removed from the units and replaced. The four units on loan to the RMI plant are serviced annually.

3.2.5 Special Surveillance Activities

Stack Upgrade Work, Building 3039

In October 1981 work began on phase I of the job to upgrade the stack at Building 3039. This phase consists of bypassing the remaining lines still in use and associated with the out-of-service precipitator and then removing the precipitator and connecting equipment. Because dose rates up to 60 rad/h (0.6 Gy/h) and extensive contamination within the system were expected, full-time coverage by the R&SS Section was required. Onsite coverage included surveys to establish contamination levels and working dose rates, as well as ALARA considerations such as the optimum use of lead shielding and contamination containment structures. The R&SS staff was also involved in several meetings with project engineers. At these meetings alternative methods of demolition were developed to further keep personnel exposures ALARA, such as the use of a strap-on air saw that could be operated from a distance. At the end of 1981, all major bypasses had been completed, and work was beginning on the demolition of the precipitator.

Upgrade of 86-in. Cyclotron, Building 9201-2

Surveillance was provided during modification of various components of the 86-in. cyclotron at the Y-12 Plant. The purpose of the modifications was to increase the efficiency, output quality, and reliability of the machine to desired levels, as well as to increase the efficiency and effectiveness of the machine operators and to achieve a more acceptable level of safety. The work was completed with a person-rem exposure burden considerably below that projected in conceptual design studies. This upgrade has achieved, among other objectives, a reduction in radiation exposures sustained by operating personnel to levels more in line with the ALARA philosophy.

3.2.6 Radiation Incidents

The term *radiation incident* is used to classify an unexpected and undesirable operational occurrence involving radiation or radioactive materials; the term is further defined in procedure 2.6 of the *ORNL Health Physics Manual*. In 1981, there were four minor radiation incidents.

4. Environmental Management Program

During CY 1981, the Department of Environmental Management was composed of four groups: Environmental Surveillance, Environmental Protection, Environmental Data Assessment, and Hazardous Materials Management and Disposal.

4.1 DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

The Department of Environmental Management of the IS&AHP Division uses three separate monitoring networks to monitor for airborne radioactivity in eastern Tennessee. The local air monitoring (LAM) network consists of 23 stations positioned relatively close to ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations located on the perimeter of the DOE-controlled area and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment; and the remote air monitoring (RAM) network consists of seven stations located outside the DOE-controlled area at distances of 12–75 miles (19–121 km) from ORNL (see Figs. 4.1–4.4). These monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques; (2) radioparticulate fallout material by impingement on gummed paper trays; (3) rainwater for measurement of fallout occurring as rainout; (4) radioiodine, using charcoal cartridges; and (5) tritium, using silica gel (used only in selected LAM stations).

After treatment, low-level radioactive liquid wastes originating from ORNL operations are discharged to White Oak Creek, a small tributary of the Clinch River. The radioactive content of the White Oak Creek discharge is determined at White Oak Dam, which is the last control point along the stream prior to the entry of White Oak Creek into the Clinch River. Water samples are also collected at several locations in the Clinch River, beginning at a point above the entry of the wastes into the river and ending at Kingston Water Plant near Kingston, Tennessee, the nearest population center downstream (Fig. 4.5).

Samples of White Oak Creek effluent are collected at White Oak Dam by a continuous proportional sampler and analyzed weekly for gross beta, gross alpha, ^{3}H, ^{60}Co, ^{90}Sr, ^{106}Ru, ^{137}Cs, plutonium, and transplutonium elements. Calculations are made of the concentrations of radioactivity in the Clinch River at the point of entry of White Oak Creek [Clinch River Mile (CRM) 20.8], using the concentrations measured at White Oak Dam and the dilution provided by the Clinch River. To verify the calculated concentrations, two sampling stations are maintained in the Clinch River below the point of entry of the wastes: one at the Oak Ridge Gaseous Diffusion Plant (ORGDP) water intake (CRM 14.5) and the other at the Kingston Water Plant [Tennessee River Mile (TRM) 568, near CRM 0.0]. An additional sampling station is maintained in the Clinch River at Melton Hill Dam (CRM 23.1) above the point of entry of the waste to provide baseline data and at the mouth of White Oak Creek (CRM 20.8) for backup measurements of the White Oak Dam station.

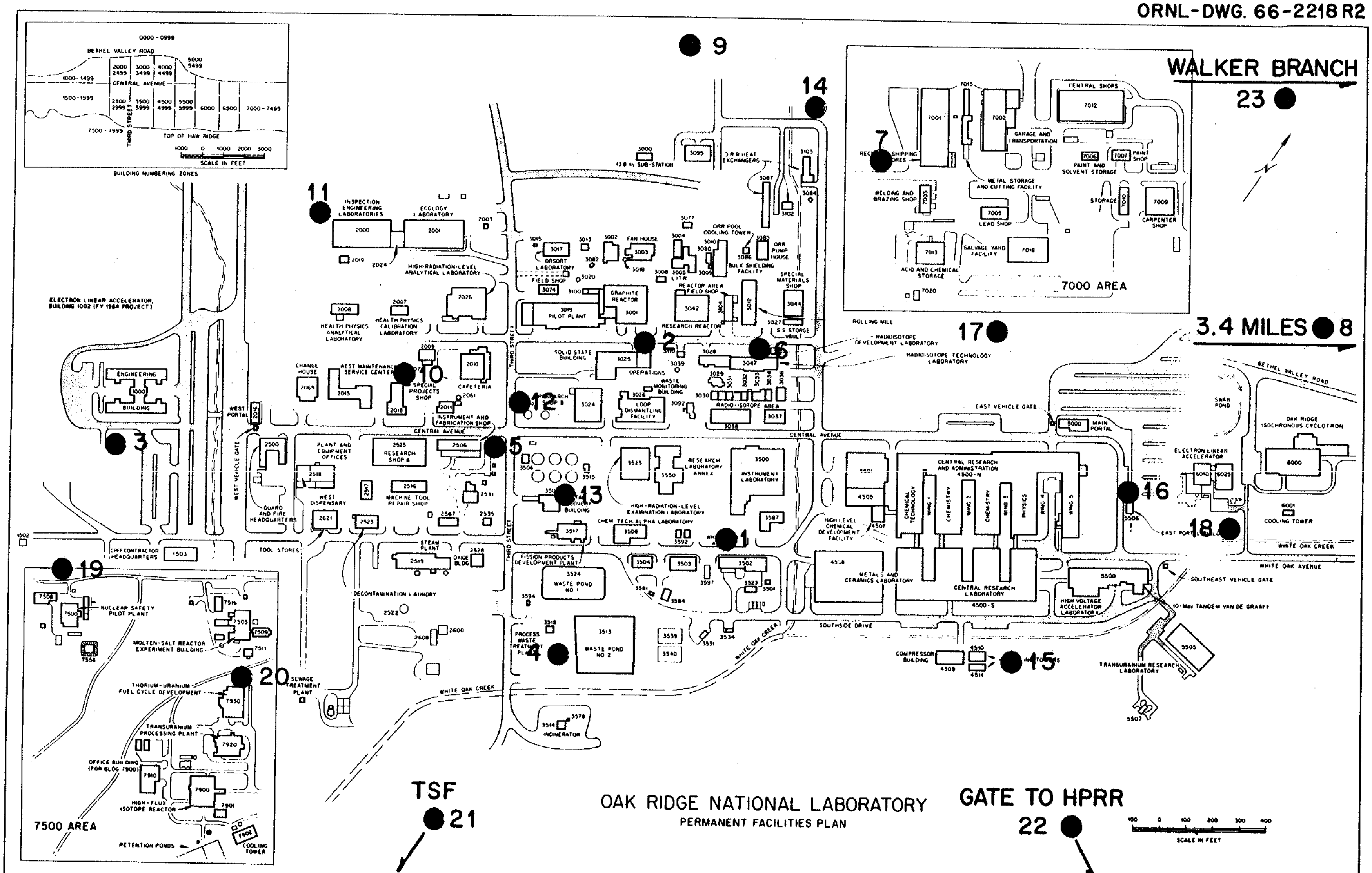

Fig. 4.1. Local air monitoring (LAM) network—Bethel Valley.

ORNL-DWG. 66-1718R

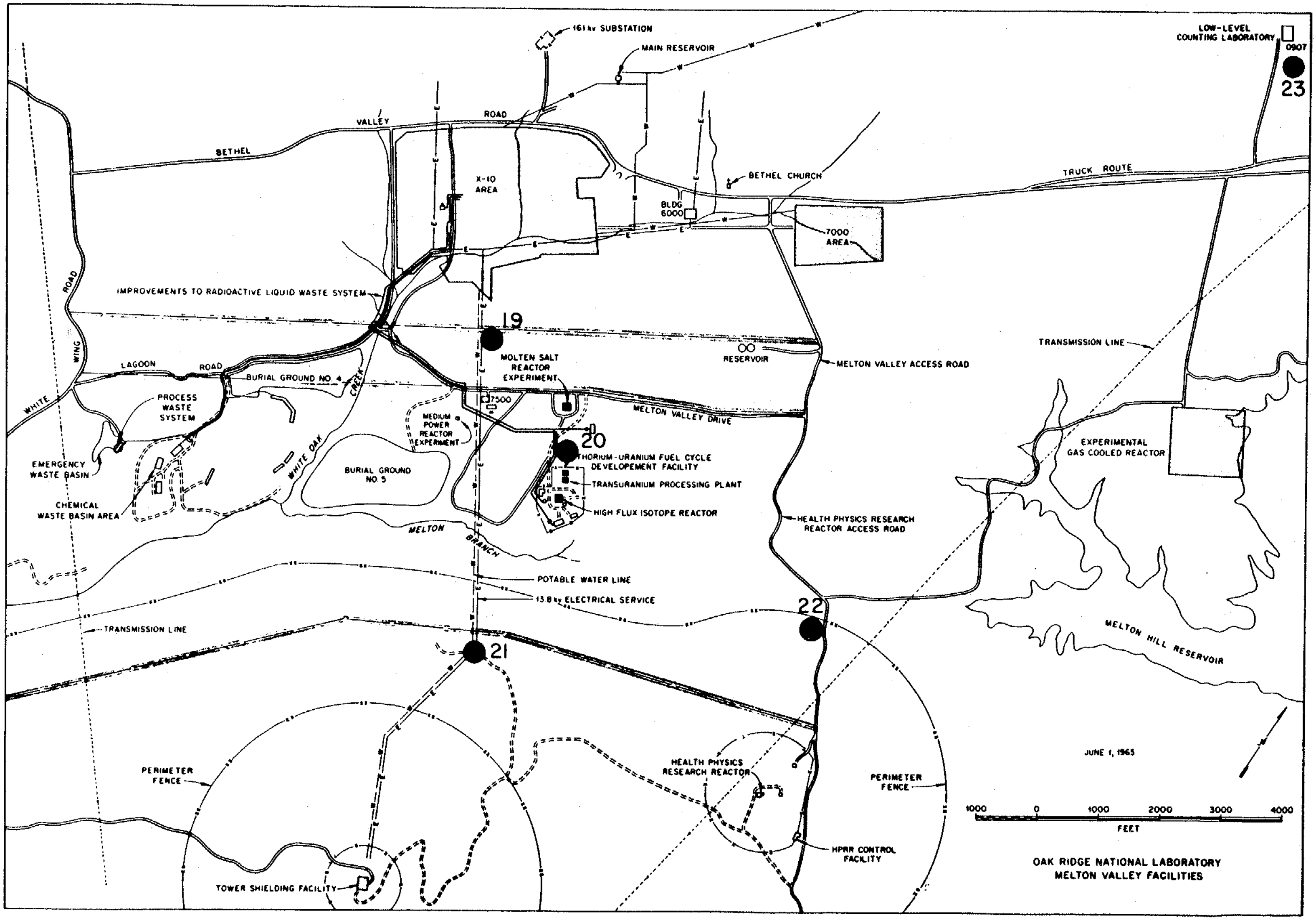

Fig. 4.2. Local air monitoring (LAM) network—Melton Valley.

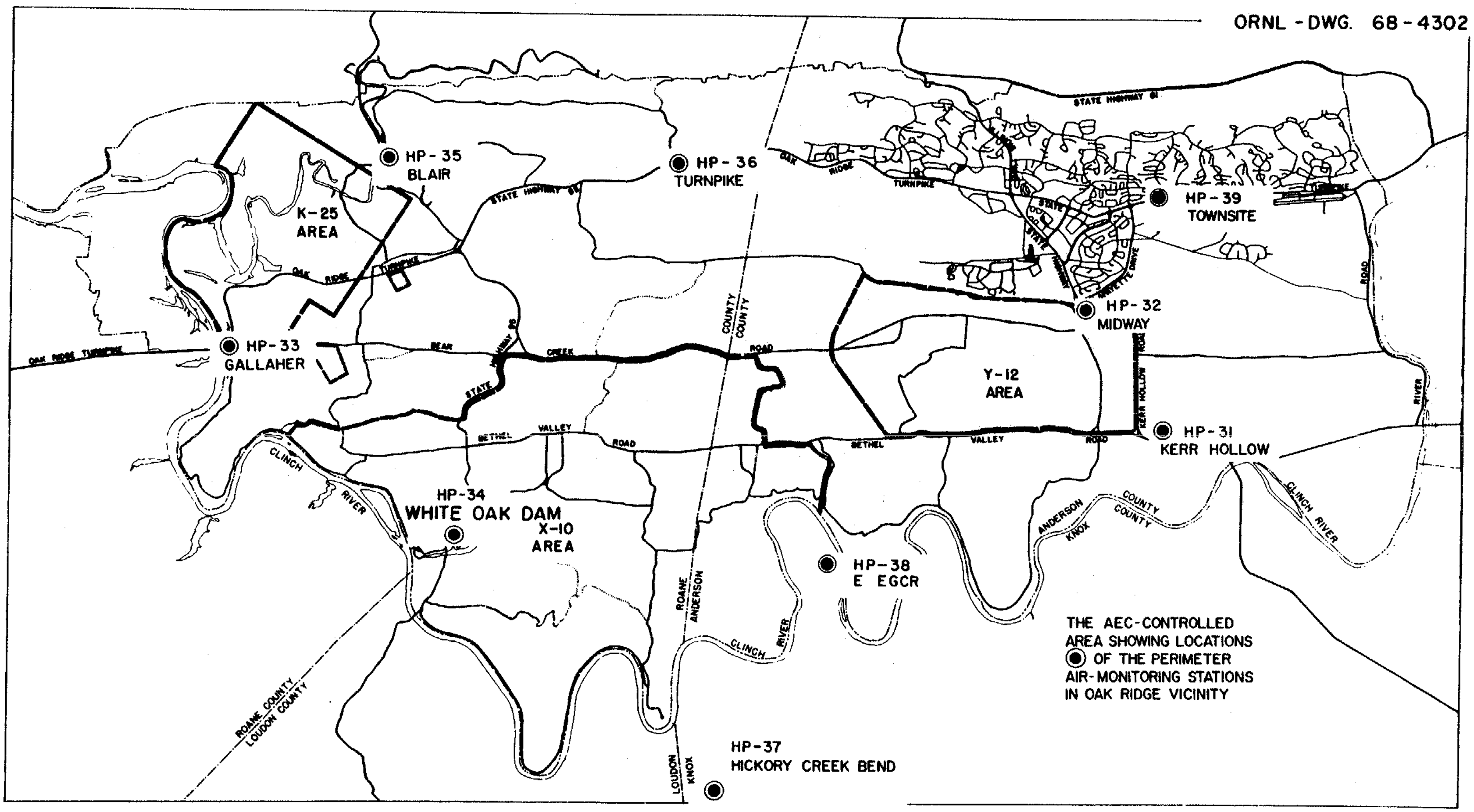

Fig. 4.3. Perimeter air monitoring (PAM) network.

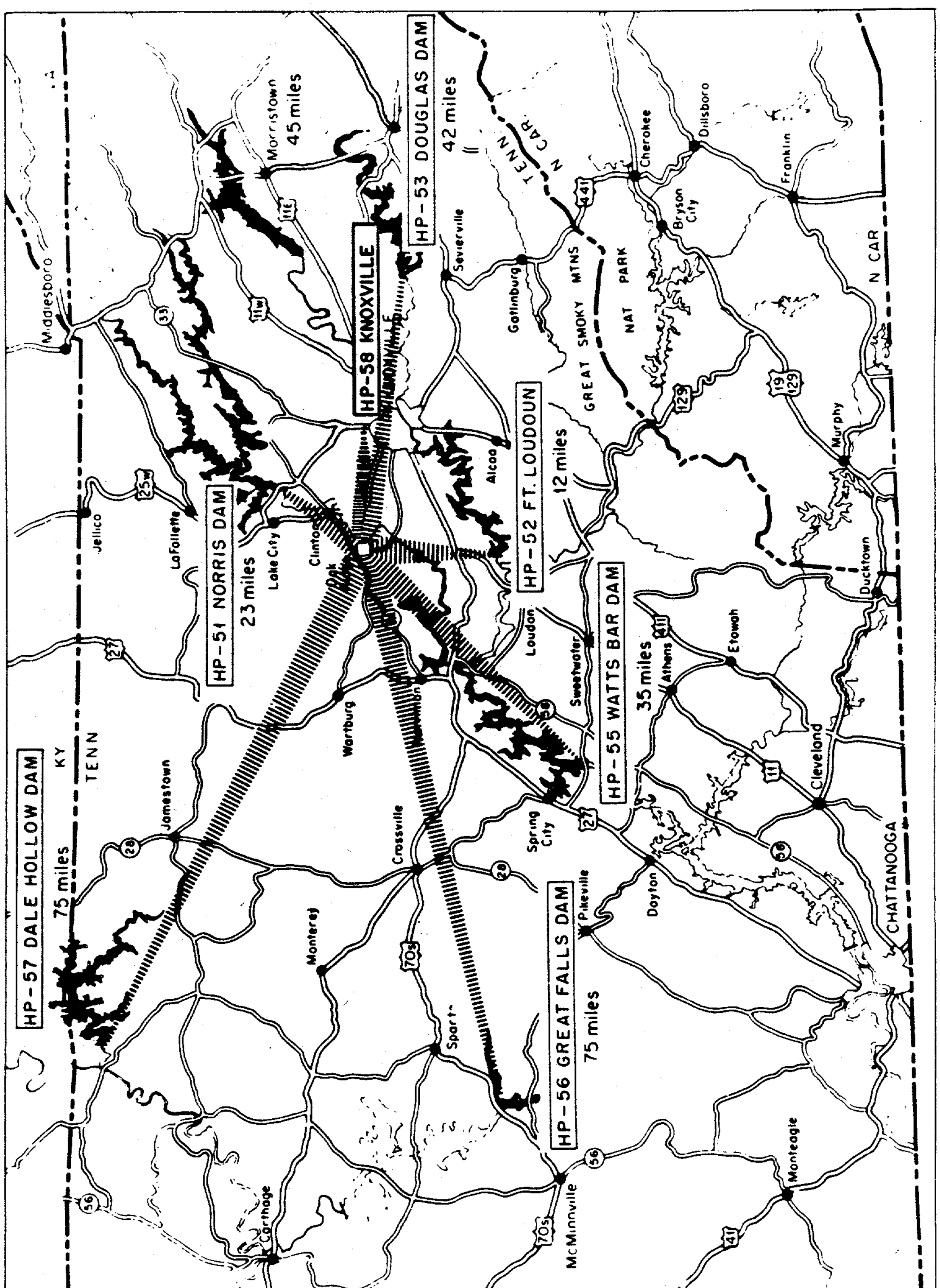

Fig. 4.4. Remote air monitoring (RAM) network.

ORNL-DWG. 66-2216R2

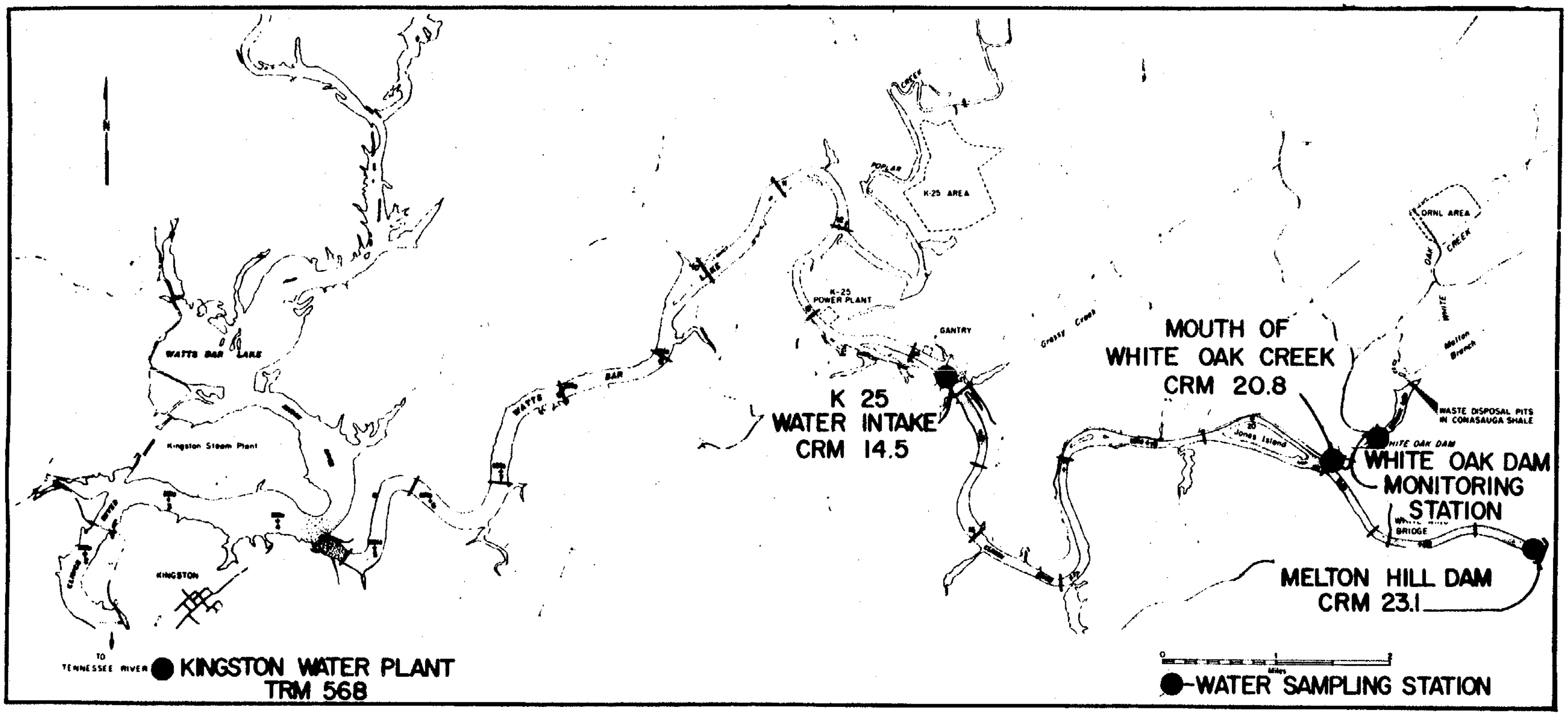

Fig. 4.5. Map showing water sampling locations in eastern Tennessee.

The ORGDP water sampling station collects a sample from the Clinch River proportional to the flow in the river near the water intake of the ORGDP water system. The samples are brought into the Laboratory at weekly intervals, and an aliquot is composited for quarterly analysis of tritium. The remaining portion of the sample is passed over anion and cation resins to remove nuclides. At quarterly intervals, the resin columns are eluted, and the eluate is analyzed for gross activity and for individual radionuclides that may be present in significant amounts.

A grab sample is collected daily at the Kingston Water Plant sampling station, which is located near the mouth of the Clinch River at TRM 568. The daily grab samples are composited and analyzed quarterly. The preparation of these samples and the analyses performed are the same as those for the ORGDP water sampling station.

The Melton Hill Dam sampling station collects a sample proportional to the flow of water through the power-generating turbines, which represents all of the discharge from the dam other than a minor amount discharged in the operation of the locks. Samples are collected from the station weekly and are processed and analyzed in the same manner as for the ORGDP water sampling station.

Samples of ORNL's potable water are collected daily and are composited and stored. At the end of each quarter, these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma-emitting radionuclides by gamma spectrometry.

Raw milk is collected at 12 sampling stations located within a radius of 50 miles (80 km) from ORNL. Samples are taken weekly from seven stations located outside the DOE-controlled area within a 20-mile (32-km) radius of ORNL (Fig. 4.6). Samples are collected every five weeks from the five remaining stations located more remotely with respect to Oak Ridge operations, out to distances of about 50 miles (80 km) (Fig. 4.7). The purpose of the milk sampling program is twofold: (1) samples collected in the immediate vicinity of ORNL provide data by which the possible effect of effluents from ORNL operations can be evaluated and (2) samples collected remote to the immediate vicinity of ORNL provide background data essential to establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations can be evaluated. The milk samples are analyzed by radiochemical techniques for ^{90}Sr and ^{131}I. The minimum detectable concentrations of ^{90}Sr and ^{131}I in milk are 0.5 and 0.45 pCi/L (18.5 and 16.7 mBq/L), respectively.

External gamma radiation background measurements are made routinely at the LAM, PAM, and RAM stations and at one station located near Melton Hill Dam. Measurements are made using calcium fluoride thermoluminescent dosimeters suspended 1 m above the ground. Dosimeters at the PAM stations and Melton Hill Dam are collected and analyzed monthly, whereas those at local and remote stations are collected and analyzed semiannually.

External gamma radiation measurements are also made routinely along the banks of the Clinch River from the mouth of White Oak Creek to points several hundred yards downstream (Fig. 4.8). These measurements are used to evaluate gamma radiation levels resulting from ORNL liquid effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the riverbank. Radiation measurements are made using lithium fluoride thermoluminescent dosimeters suspended 1 m above the ground surface.

Various species of fish that are commonly caught and eaten in eastern Tennessee are taken from the Clinch River quarterly from CRM 20.8 (intersection of White Oak Creek and the Clinch River) and annually from other locations in the Clinch River. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometric and radiochemical techniques for the critical radionuclides that may contribute significantly to the potential radiation dose to man.

Soil and grass samples are collected semiannually and annually, respectively, from locations near the PAM and RAM stations. Two samples, about 8 cm in diameter and 5 cm thick, are collected from

ORNL-DWG 64-3713R4

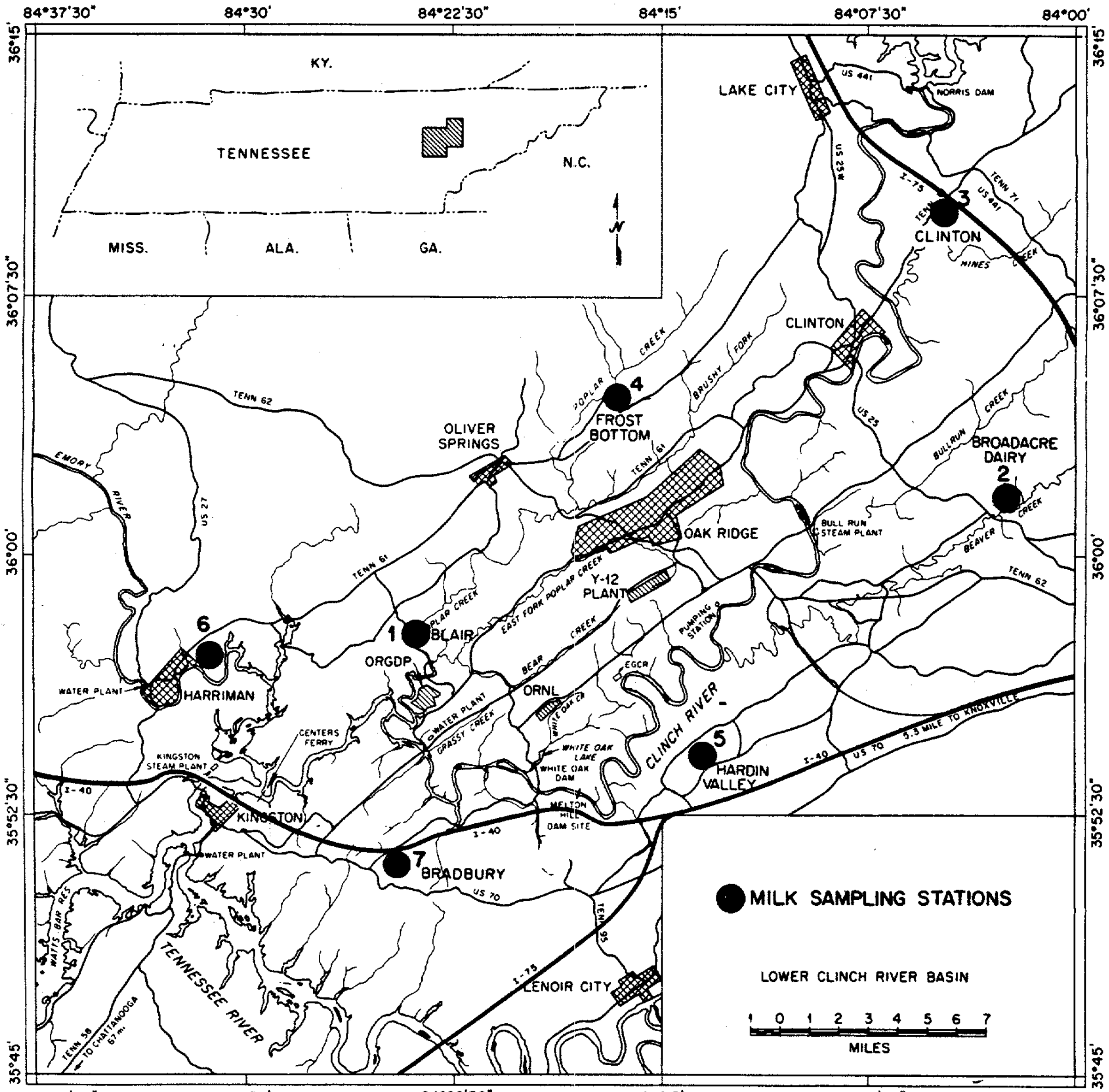

Fig. 4.6. Location of milk sampling stations [within 20-mile (32 km) radius of ORNL].

five 400-cm^2 plots (for a total of ten samples at each location) and are composited and analyzed by gamma spectroscopy and radiochemical techniques for uranium, plutonium, and various other radioisotopes.

4.2 ENVIRONMENTAL MANAGEMENT

The major Environmental Management functions during 1981 were:

1. coordinating the Laboratory's pollution abatement and monitoring programs;
2. serving as liaison among the various ORNL groups involved in pollution control, ORNL management, and the UCC-ND Office of Safety and Environmental Protection;

ORNL DWG 76-12775RAR2

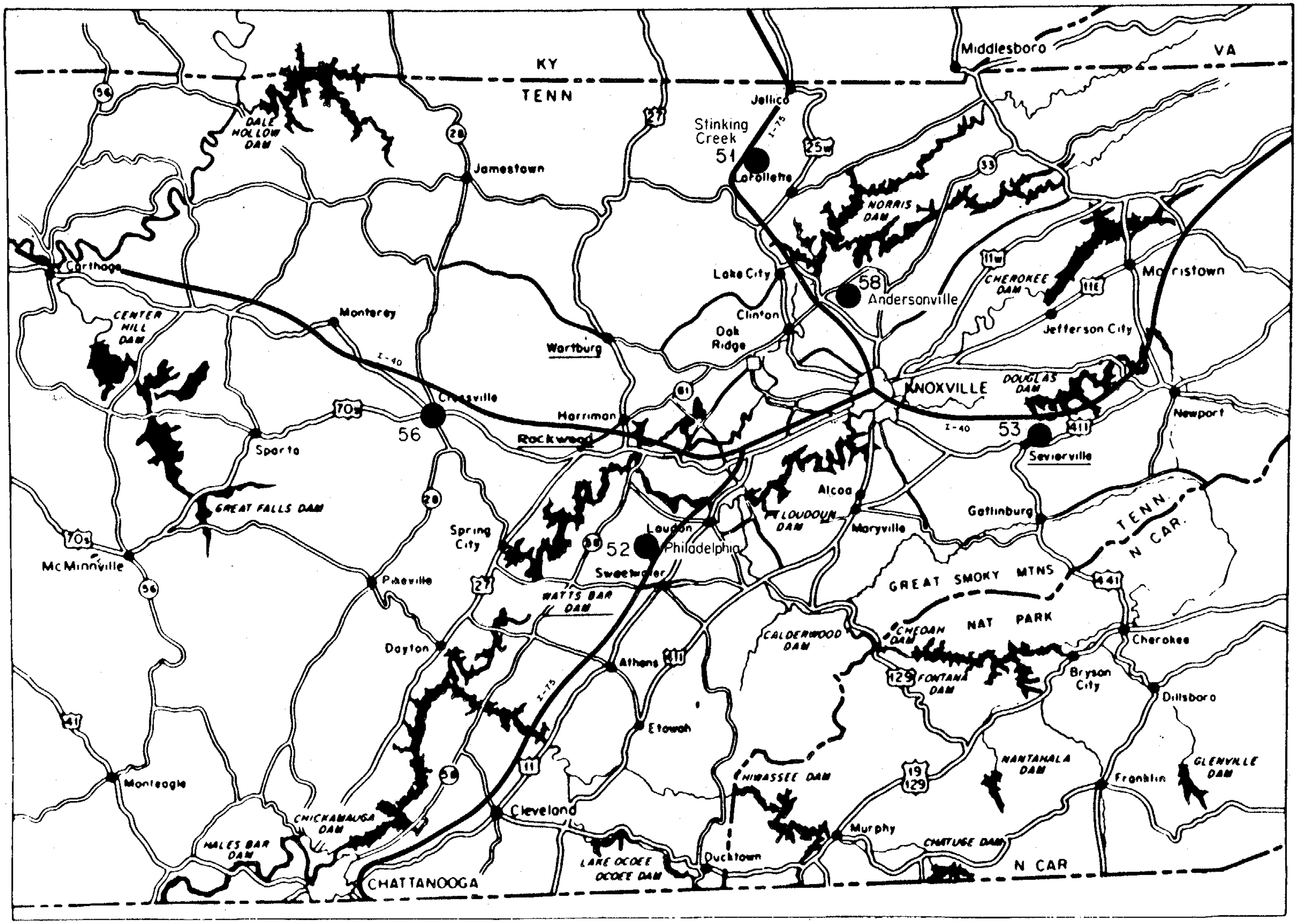

Fig. 4.7. Milk sampling stations for remote environs [about 50 miles (80 km) from Oak Ridge operations].

ORNL DWG 76-12776

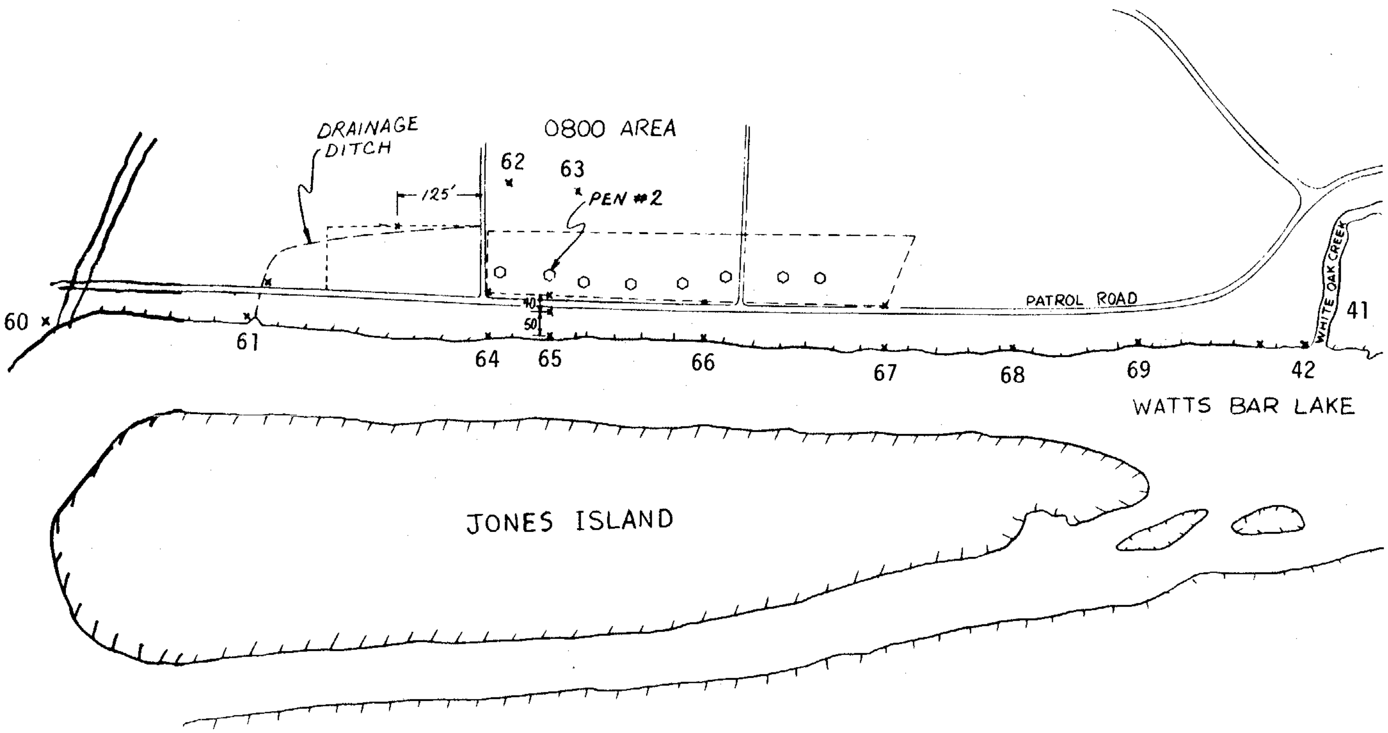

Fig. 4.8. Thermoluminescent dosimeter locations along the perimeter of the DOE–Oak Ridge controlled area.

3. determining the pollutants (radioactive and nonradioactive) to be monitored in effluents and environmental media and the location and frequency of the measurements;
4. identifying areas where development work, additional monitoring equipment, and changes in waste disposal practices are required for pollution abatement;
5. maintaining adequate records on significant effluents within the installation;
6. reviewing, or providing for review, the design, acquisition, and installation of required pollution control equipment;
7. preparing environmental assessments for those Laboratory construction projects that require them;
8. preparing monthly, quarterly, and annual reports on radioactive and nonradioactive effluents, as required by UCC-ND management and DOE; and
9. reviewing Laboratory construction projects for environmental impact.

4.3 ATMOSPHERIC MONITORING

4.3.1 Air Concentrations

The average concentrations of alpha radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1981, were:

Network	Concentration [μCi/cc (Bq/m^3)]
LAM	2.0E−15 (0.75E−4)
PAM	0.89E−15 (0.33E−4)
RAM	1.1E−15 (0.39E−4)

All networks are less than 10% of 2.0E−14 μCi/cc (0.74E−3 Bq/m^3), the average concentration guide in air (CG_a)[1] for a mixture of airborne uranium isotopes in an uncontrolled area. The values for each station are given in Table 4.1.

The average concentrations of beta radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1981, were:

Network	Concentration [μCi/cc (Bq/m^3)]
LAM	0.89E−13 (0.31E−2)
PAM	0.69E−13 (0.25E−2)
RAM	0.70E−13 (0.25E−2)

The LAM network value of 0.89E−13 μCi/cc (0.31E−2 Bq/m^3) is less than 0.002% of the CG_a based on an occupational exposure of 3E−9 μCi/cc (1.1E2 Bq/m^3). Both the LAM and PAM network values represent <0.07% of the CG_aU of 1.0E−10 μCi/cc (3.7 Bq/m^3) applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 4.2, and the weekly values for each network are illustrated in Table 4.3.

4.3.2 Fallout (Gummed Paper Technique)

Table 4.4 gives the average activity per square meter on gummed paper for the three air monitoring networks.

1. DOE Order 5480.1, Chap. XI.

Table 4.1. Concentration of alpha activity in air, 1981

Filter paper data—annual average

Station No.[a]	Location	Long-lived activity	
		μCi/cc	Bq/m^3
	Laboratory area		
HP-1	S 3587	0.14E−14	0.52E−4
HP-2	NE 3025	0.15E−14	0.55E−4
HP-3	SW 1000	0.24E−14	0.87E−4
HP-4	W Settling Basin	0.13E−14	0.49E−4
HP-5	E 2506	0.22E−14	0.81E−4
HP-6	SW 3027	0.19E−14	0.69E−4
HP-7	W 7001	0.19E−14	0.70E−4
HP-8	Rock Quarry	0.17E−14	0.62E−4
HP-9	N Bethel Valley Road	0.19E−14	0.70E−4
HP-10	W 2075	0.62E−14	0.23E−3
HP-16	E 4500	0.14E−14	0.52E−4
HP-20	HFIR	0.16E−14	0.59E−4
HP-23	Walker Branch	0.11E−14	0.41E−4
Average		0.20E−14	0.75E−4
	Perimeter area		
HP-31	Kerr Hollow Gate	0.79E−15	0.29E−4
HP-32	Midway Gate	0.11E−14	0.42E−4
HP-33	Gallaher Gate	0.85E−15	0.31E−4
HP-34	White Oak Dam	0.92E−15	0.34E−4
HP-35	Blair Gate	0.89E−15	0.33E−4
HP-36	Turnpike Gate	0.82E−15	0.30E−4
HP-37	Hickory Creek Bend	0.92E−15	0.34E−4
HP-38	E EGCR	0.86E−15	0.32E−4
HP-39	Townsite	0.84E−15	0.31E−4
Average		0.89E−15	0.33E−4
	Remote area		
HP-51	Norris Dam	0.10E−14	0.37E−4
HP-52	Loudoun Dam	0.96E−15	0.36E−4
HP-53	Douglas Dam	0.11E−14	0.40E−4
HP-55	Watts Bar Dam	0.13E−14	0.50E−4
HP-56	Great Falls Dam	0.12E−14	0.46E−4
HP-57	Dale Hollow Dam	0.99E−15	0.36E−4
HP-58	Knoxville	0.88E−15	0.33E−4
Average		0.11E−14	0.40E−4

[a]See Figs. 4.1–4.4 for station locations.

4.3.3 Rainout (Gross Analysis of Rainwater)

The average concentration of beta radioactivity in rainwater collected from the three networks during 1981 was:

Network	Concentration [μCi/cc (Bq/m^3)]
LAM	0.37E−07 (0.14E4)
PAM	0.27E−07 (0.10E4)
RAM	0.43E−07 (0.16E4)

Table 4.2. Concentration of beta radioactivity in air, 1981

Filter paper data—annual average

Station No.[a]	Location	Long-lived activity	
		μCi/cc	Bq/m^3
	Laboratory area		
HP-1	S 3587	0.87E−13	0.32E−2
HP-2	NE 3025	0.86E−13	0.32E−2
HP-3	SW 1000	0.73E−13	0.27E−2
HP-4	W Settling Basin	0.79E−13	0.29E−2
HP-5	E 2506	0.79E−13	0.29E−2
HP-6	SW 3027	0.87E−13	0.32E−2
HP-7	W 7001	0.86E−13	0.32E−2
HP-8	Rock Quarry	0.83E−13	0.31E−2
HP-9	N Bethel Valley Road	0.80E−13	0.30E−2
HP-10	W 2075	0.92E−13	0.34E−2
HP-16	E 4500	0.79E−13	0.29E−2
HP-20	HFIR	0.87E−13	0.32E−2
HP-23	Walker Branch	0.81E−13	0.30E−2
Average		0.83E−13	0.31E−2
	Perimeter area		
HP-31	Kerr Hollow Gate	0.68E−13	0.25E−2
HP-32	Midway Gate	0.73E−13	0.27E−2
HP-33	Gallaher Gate	0.68E−13	0.25E−2
HP-34	White Oak Dam	0.85E−13	0.32E−2
HP-35	Blair Gate	0.72E−13	0.27E−2
HP-36	Turnpike Gate	0.59E−13	0.22E−2
HP-37	Hickory Creek Bend	0.60E−13	0.22E−2
HP-38	E EGCR	0.80E−13	0.30E−2
HP-39	Townsite	0.57E−13	0.21E−2
Average		0.69E−13	0.26E−2
	Remote area		
HP-51	Norris Dam	0.73E−13	0.27E−2
HP-52	Loudoun Dam	0.74E−13	0.27E−2
HP-53	Douglas Dam	0.68E−13	0.25E−2
HP-55	Watts Bar Dam	0.55E−13	0.20E−2
HP-56	Great Falls Dam	0.64E−13	0.24E−2
HP-57	Dale Hollow Dam	0.86E−13	0.32E−2
HP-58	Knoxville	0.67E−13	0.25E−2
Average		0.70E−13	0.26E−2

[a]See Figs. 4.1–4.4 for station locations.

The average concentration measured at each station within each network is presented in Table 4.5, and the average concentration for each network for each week is given in Table 4.6.

4.3.4 Atmospheric Radioiodine (Charcoal Cartridge Technique)

Atmospheric iodine sampled at the perimeter stations averaged 0.13E−14 μCi/cc (0.47E−4 Bq/m^3) during 1981. This average represents <0.005% of the concentration guide of 1E−10 μCi/cc (3.7 Bq/m^3) applicable to inhalation of ^{131}I released to uncontrolled areas. The maximum concentration observed for one week was 0.32E−14 μCi/cc (0.12E−3 Bq/m^3).

Table 4.3. Concentration of beta radioactivity in air, 1981

Filter paper data—system average by week

Week No.	Local		Perimeter		Remote	
	μCi/cc	Bq/m³	μCi/cc	Bq/m³	μCi/cc	Bq/m³
1	0.13E−12	0.48E−2	0.65E−13	0.24E−2	0.75E−13	0.28E−2
2	0.14E−12	0.50E−2	0.95E−13	0.35E−2	0.11E−12	0.40E−2
3	0.80E−13	0.30E−2	0.47E−13	0.17E−2	0.63E−13	0.23E−2
4	0.11E−12	0.41E−2	0.93E−13	0.34E−2	0.89E−13	0.33E−2
5	0.11E−12	0.41E−2	0.95E−13	0.35E−2	0.83E−13	0.31E−2
6	0.92E−13	0.34E−2	0.71E−13	0.26E−2	0.77E−13	0.28E−2
7	0.13E−12	0.49E−2	0.91E−13	0.34E−2	0.89E−13	0.33E−2
8	0.39E−13	0.14E−2	0.34E−13	0.13E−2	0.43E−13	0.16E−2
9	0.12E−12	0.45E−2	0.98E−13	0.36E−2	0.10E−12	0.38E−2
10	0.72E−13	0.27E−2	0.65E−13	0.24E−2	0.77E−13	0.28E−2
11	0.15E−12	0.56E−2	0.12E−12	0.45E−2	0.12E−12	0.45E−2
12	0.13E−12	0.48E−2	0.11E−12	0.41E−2	0.12E−12	0.45E−2
13	0.19E−12	0.69E−2	0.18E−12	0.67E−2	0.17E−12	0.62E−2
14	0.33E−12	0.12E−1	0.31E−12	0.11E−1	0.30E−12	0.11E−1
15	0.33E−12	0.12E−1	0.30E−12	0.11E−1	0.25E−12	0.93E−2
16	0.23E−12	0.84E−2	0.19E−12	0.71E−2	0.19E−12	0.69E−2
17	0.16E−12	0.60E−2	0.13E−12	0.50E−2	0.10E−12	0.39E−2
18	0.18E−12	0.65E−2	0.16E−12	0.58E−2	0.14E−12	0.53E−2
19	0.14E−12	0.52E−2	0.13E−12	0.47E−2	0.11E−12	0.39E−2
20	0.10E−12	0.39E−2	0.75E−13	0.28E−2	0.79E−13	0.29E−2
21	0.12E−12	0.45E−2	0.11E−12	0.41E−2	0.10E−12	0.38E−2
22	0.82E−13	0.30E−2	0.59E−13	0.22E−2	0.87E−13	0.32E−2
23	0.24E−13	0.87E−3	0.22E−13	0.81E−3	0.24E−13	0.91E−3
24	0.54E−13	0.20E−2	0.47E−13	0.17E−2	0.37E−13	0.14E−2
25	0.93E−13	0.34E−2	0.74E−13	0.27E−2	0.67E−13	0.25E−2
26	0.79E−13	0.29E−2	0.86E−13	0.32E−2	0.90E−13	0.33E−2
27	0.75E−13	0.28E−2	0.69E−13	0.26E−2	0.67E−13	0.25E−2
28	0.45E−13	0.17E−2	0.25E−13	0.92E−3	0.43E−13	0.16E−2
29	0.38E−13	0.14E−2	0.37E−13	0.14E−2	0.33E−13	0.12E−2
30	0.40E−13	0.15E−2	0.32E−13	0.12E−2	0.33E−13	0.12E−2
31	0.19E−13	0.69E−3	0.21E−13	0.78E−3	0.18E−13	0.65E−3
32	0.22E−13	0.83E−3	0.16E−13	0.59E−3	0.25E−13	0.91E−3
33	0.64E−13	0.24E−2	0.45E−13	0.17E−2	0.47E−13	0.17E−2
34	0.51E−13	0.19E−2	0.41E−13	0.15E−2	0.44E−13	0.16E−2
35	0.62E−13	0.23E−2	0.50E−13	0.18E−2	0.48E−13	0.18E−2
36	0.27E−13	0.10E−2	0.23E−13	0.84E−3	0.23E−13	0.85E−3
37	0.42E−13	0.15E−2	0.38E−13	0.14E−2	0.38E−13	0.14E−2
38	0.22E−13	0.82E−3	0.17E−13	0.64E−3	0.24E−13	0.90E−3
39	0.41E−13	0.15E−2	0.34E−13	0.13E−2	0.51E−13	0.19E−2
40	0.48E−13	0.18E−2	0.29E−13	0.11E−2	0.26E−13	0.98E−3
41	0.38E−13	0.14E−2	0.28E−13	0.10E−2	0.30E−13	0.11E−2
42	0.44E−13	0.16E−2	0.30E−13	0.11E−2	0.30E−13	0.11E−2
43	0.39E−13	0.14E−2	0.27E−13	0.99E−3	0.52E−13	0.19E−2
44	0.17E−13	0.62E−3	0.17E−13	0.64E−3	0.18E−13	0.68E−3
45	0.24E−13	0.87E−3	0.15E−13	0.55E−3	0.15E−13	0.57E−3
46	0.37E−13	0.14E−2	0.31E−13	0.12E−2	0.28E−13	0.10E−2
47	0.23E−13	0.84E−3	0.19E−13	0.70E−3	0.23E−13	0.84E−3
48	0.17E−13	0.62E−3	0.18E−13	0.68E−3	0.19E−13	0.71E−3
49	0.15E−13	0.57E−3	0.11E−13	0.40E−3	0.10E−13	0.37E−3
50	0.21E−13	0.77E−3	0.19E−13	0.70E−3	0.16E−13	0.61E−3
51	0.25E−13	0.91E−3	0.22E−13	0.80E−3	0.19E−13	0.70E−3
52	0.10E−13	0.37E−3	0.12E−13	0.44E−3	0.15E−13	0.56E−3
Average	0.83E−13	0.31E−2	0.69E−13	0.26E−2	0.69E−13	0.26E−2

Table 4.4. Radioparticulate fallout per square foot (square meter), 1981

Gummed paper data—station annual average

Station No.[a]	Location	Long-lived activity	
		μCi/ft^2	Bq/m^2
	Laboratory area		
HP-1	S 3587	0.50E−5	0.20E1
HP-2	NE 3025	0.46E−5	0.18E1
HP-3	SW 1000	0.50E−5	0.20E1
HP-4	W Settling Basin	0.46E−5	0.18E1
HP-5	E 2506	0.47E−5	0.19E1
HP-6	SW 3027	0.56E−5	0.22E1
HP-7	W 7001	0.33E−5	0.13E1
HP-8	Rock Quarry	0.44E−5	0.17E1
HP-9	N Bethel Valley Road	0.45E−5	0.18E1
HP-10	W 2075	0.47E−5	0.19E1
HP-16	E 4500	0.43E−5	0.17E1
HP-20	HFIR	0.43E−5	0.17E1
HP-23	Walker Branch	0.46E−5	0.18E1
Average		0.46E−5	0.18E1
	Perimeter area		
HP-31	Kerr Hollow Gate	0.42E−5	0.17E1
HP-32	Midway Gate	0.41E−5	0.16E1
HP-33	Gallaher Gate	0.49E−5	0.19E1
HP-34	White Oak Dam	0.48E−5	0.19E1
HP-35	Blair Gate	0.50E−5	0.20E1
HP-36	Turnpike Gate	0.45E−5	0.18E1
HP-37	Hickory Creek Bend	0.40E−5	0.16E1
HP-38	E EGCR	0.46E−5	0.18E1
HP-39	Townsite	0.45E−5	0.18E1
Average		0.45E−5	0.18E1
	Remote area		
HP-51	Norris Dam	0.42E−5	0.17E1
HP-52	Loudoun Dam	0.37E−5	0.15E1
HP-53	Douglas Dam	0.46E−5	0.18E1
HP-55	Watts Bar Dam	0.34E−5	0.13E1
HP-56	Great Falls Dam	0.45E−5	0.18E1
HP-57	Dale Hollow Dam	0.45E−5	0.18E1
HP-58	Knoxville	0.44E−5	0.18E1
Average		0.42E−5	0.17E1

[a] See Figs. 4.1–4.4 for station locations.

The average radioiodine concentration at the local stations was 0.35E−14 μCi/cc (0.13E−3 Bq/m^3). This concentration is <0.001% of the concentration guide for inhalation by occupational personnel. The maximum concentration for one week was 0.24E−13 μCi/cc (0.88E−3 Bq/m^3).

Table 4.7 presents the ^{131}I weekly average concentration data for the LAM and PAM networks. The weekly average ^{131}I concentration in air measured by stations in the LAM and PAM networks is given in Table 4.8. Tables 4.9 and 4.10 give results of the specific radionuclide analyses of the filters from the three networks.

Table 4.5. Concentration of beta activity in rainwater, 1981

Annual average by station

Station No.[a]	Location	Long-lived activity	
		μCi/cc	Bq/m^3
	Laboratory area		
HP-7	W 7001	0.29E−7	0.11E4
HP-23	Walker Branch	0.45E−7	0.17E4
Average		0.37E−7	0.14E4
	Perimeter area		
HP-31	Kerr Hollow Gate	0.25E−7	0.93E3
HP-32	Midway Gate	0.24E−7	0.87E3
HP-33	Gallaher Gate	0.31E−7	0.11E4
HP-34	White Oak Dam	0.23E−7	0.87E3
HP-35	Blair Gate	0.25E−7	0.92E3
HP-36	Turnpike Gate	0.25E−7	0.94E3
HP-37	Hickory Creek Bend	0.25E−7	0.94E3
HP-38	E EGCR	0.36E−7	0.13E4
HP-39	Townsite	0.29E−7	0.11E4
Average		0.27E−7	0.10E4
	Remote area		
HP-51	Norris Dam	0.54E−7	0.20E4
HP-52	Loudoun Dam	0.37E−7	0.14E4
HP-53	Douglas Dam	0.56E−7	0.21E4
HP-55	Watts Bar Dam	0.34E−7	0.13E4
HP-56	Great Falls Dam	0.37E−7	0.14E4
HP-57	Dale Hollow Dam	0.48E−7	0.18E4
HP-58	Knoxville	0.31E−7	0.12E4
Average		0.43E−7	0.16E4

[a]See Figs. 4.1–4.4 for station locations.

4.3.5 Nonradioactive Air Particulates

Environmental air sampling for nonradioactive air particulates was initiated in 1980 at ORNL because of the conversion of the steam plant from gas to coal fuel.

Suspended particulates are measured at air monitoring stations 1, 3, 6, 7, and 15 (Fig. 4.1). The method for the determination of suspended particulates is the high-volume method recommended by the Environmental Protection Agency (EPA). Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity-controlled atmosphere and is reweighed. From the weight of particulates, the sampling time, and the airflow rate, the particulate concentration is calculated, in micrograms per cubic meter. The sampling period is 24 h. Air monitoring data for suspended particulates are presented in Table 4.11. All samples taken had values below the allowable standards.

4.3.6 Milk Analysis

The yearly average and maximum concentrations of ^{90}Sr and ^{131}I in raw milk are given in Tables 4.12 and 4.13, respectively. If the average intake of milk per individual is assumed to be 1 L/d, the concentrations of ^{131}I in milk collected near ORNL and from more remotely located stations are within

Table 4.6. Concentration of beta radioactivity in rainwater, 1981

System average by week

Week No.	Local		Perimeter		Remote	
	μCi/cc	Bq/m^3	μCi/cc	Bq/m^3	μCi/cc	Bq/m^3
1	−0.10E1[a]	−0.10E1	−0.10E1	−0.10E1	−0.10E1	−0.10E1
2	0.73E−7	0.27E4	0.26E−7	0.98E3	0.56E−7	0.21E4
3	−0.10E1	−0.10E1	0.10E1	−0.10E1	0.14E−7	0.50E3
4	0.57E−7	0.21E4	0.40E−7	0.15E4	0.43E−7	0.16E4
5	0.47E−7	0.17E4	0.39E−7	0.14E4	0.70E−7	0.26E4
6	0.15E−6	0.57E4	0.56E−7	0.21E4	0.59E−7	0.22E4
7	0.26E−7	0.98E3	0.33E−7	0.12E4	0.45E−7	0.17E4
8	0.10E−6	0.38E4	0.61E−7	0.23E4	0.87E−7	0.32E4
9	0.12E−6	0.46E4	0.12E−6	0.43E4	0.11E−6	0.41E4
10	0.79E−7	0.29E4	0.44E−7	0.16E4	0.61E−7	0.23E4
11	−0.10E1	−0.10E1	0.64E−7	0.24E4	0.12E−6	0.44E4
12	0.57E−7	0.21E4	0.47E−7	0.17E4	0.81E−7	0.30E4
13	0.44E−7	0.16E4	0.36E−7	0.13E4	0.37E−7	0.14E4
14	0.38E−7	0.14E4	0.34E−7	0.13E4	0.42E−7	0.16E4
15	0.61E−7	0.23E4	0.41E−7	0.15E4	0.73E−7	0.27E4
16	0.81E−7	0.30E4	0.46E−7	0.17E4	0.58E−7	0.22E4
17	0.59E−7	0.22E4	0.36E−7	0.13E4	0.53E−7	0.20E4
18	0.32E−7	0.12E4	0.38E−7	0.14E4	0.11E−6	0.41E4
19	−0.10E1	−0.10E1	0.51E−7	0.19E4	0.57E−7	0.21E4
20	0.79E−7	0.29E4	0.57E−7	0.21E4	0.12E−6	0.44E4
21	0.83E−7	0.31E4	0.40E−7	0.15E4	0.59E−7	0.22E4
22	0.54E−7	0.20E4	0.40E−7	0.15E4	0.57E−7	0.21E4
23	0.15E−7	0.56E3	0.17E−7	0.65E3	0.36E−7	0.13E4
24	0.26E−7	0.98E3	0.17E−7	0.65E3	0.36E−7	0.13E4
25	0.27E−7	0.10E4	0.17E−7	0.61E3	0.58E−7	0.21E4
26	0.27E−7	0.10E4	0.17E−7	0.63E3	0.37E−7	0.14E4
27	0.40E−7	0.15E4	0.18E−7	0.65E3	0.48E−7	0.18E4
28	0.00	0.00	0.23E−7	0.87E3	0.47E−7	0.17E4
29	0.54E−7	0.20E4	0.10E−7	0.38E3	0.35E−7	0.13E4
30	0.16E−7	0.59E3	0.60E−8	0.22E3	0.30E−7	0.11E4
31	0.25E−7	0.93E3	0.11E−7	0.40E3	0.15E−7	0.57E3
32	0.14E−7	0.54E3	0.12E−7	0.46E3	0.24E−7	0.90E3
33	0.25E−7	0.93E3	0.24E−7	0.90E3	0.42E−7	0.16E4
34	0.20E−7	0.74E3	0.11E−7	0.40E3	0.28E−7	0.10E4
35	−0.10E1	−0.10E1	−0.10E1	−0.10E1	0.18E−7	0.67E3
36	0.12E−7	0.44E3	0.89E−8	0.33E3	0.17E−7	0.63E3
37	−0.10E1	−0.10E1	−0.10E1	−0.10E1	0.27E−7	0.10E4
38	0.10E−7	0.37E3	0.80E−8	0.30E3	0.16E−7	0.61E3
39	−0.10E1	−0.10E1	−0.10E1	−0.10E1	0.15E−7	0.56E3
40	−0.10E1	−0.10E1	0.55E−8	0.20E3	0.17E−7	0.62E3
41	−0.10E1	−0.10E1	0.10E−7	0.39E3	0.14E−7	0.52E3
42	0.13E−7	0.48E3	0.89E−8	0.33E3	0.13E−7	0.49E3
43	0.17E−7	0.63E3	0.54E−8	0.20E3	0.15E−7	0.55E3
44	0.40E−8	0.15E3	0.38E−8	0.14E3	0.76E−8	0.28E3
45	−0.10E1	−0.10E1	−0.10E1	−0.10E1	−0.10E1	−0.10E1
46	0.11E−7	0.41E3	0.12E−7	0.44E3	0.22E−7	0.81E3
47	0.24E−7	0.89E3	0.83E−8	0.31E3	0.17E−7	0.64E3
48	0.11E−7	0.43E3	0.86E−8	0.32E3	0.45E−8	0.17E3
49	0.60E−8	0.22E3	0.47E−8	0.17E3	0.29E−7	0.11E4
50	0.75E−8	0.28E3	0.72E−8	0.27E3	0.87E−8	0.32E3
51	0.18E−7	0.67E3	0.18E−7	0.68E3	0.21E−7	0.77E3
52	0.18E−7	0.67E3	0.10E−7	0.38E3	0.15E−7	0.57E3
Average	0.41E−7	0.15E4	0.27E−7	0.10E4	0.42E−7	0.16E4

[a] −0.10E1 = no sample taken.

Table 4.7. Concentration of ^{131}I in air, 1981

System weekly average

Week No.	Local		Perimeter	
	μCi/cc	Bq/m^3	μCi/cc	Bq/m^3
1	0.27E−14	0.10E−3	0.94E−15	0.35E−4
2	0.31E−14	0.11E−3	0.14E−14	0.50E−4
3	0.26E−14	0.96E−4	0.12E−14	0.45E−4
4	0.44E−14	0.16E−3	0.16E−14	0.58E−4
5	0.35E−14	0.13E−3	0.13E−14	0.48E−4
6	0.35E−14	0.13E−3	0.12E−14	0.45E−4
7	0.24E−14	0.90E−4	0.10E−14	0.39E−4
8	0.23E−14	0.87E−4	0.14E−14	0.51E−4
9	0.32E−14	0.12E−3	0.79E−15	0.29E−4
10	0.30E−14	0.11E−3	0.10E−14	0.39E−4
11	0.35E−14	0.13E−3	0.12E−14	0.43E−4
12	0.31E−14	0.11E−3	0.12E−14	0.43E−4
13	0.34E−14	0.12E−3	0.94E−15	0.35E−4
14	0.38E−14	0.14E−3	0.89E−15	0.33E−4
15	0.50E−14	0.19E−3	0.13E−14	0.50E−4
16	0.27E−14	0.99E−4	0.13E−14	0.48E−4
17	0.22E−14	0.82E−4	0.14E−14	0.53E−4
18	0.26E−14	0.96E−4	0.14E−14	0.53E−4
19	0.48E−14	0.18E−3	0.99E−15	0.37E−4
20	0.39E−14	0.14E−3	0.13E−14	0.47E−4
21	0.35E−14	0.13E−3	0.16E−14	0.60E−4
22	0.25E−14	0.93E−4	0.14E−14	0.51E−4
23	0.28E−14	0.10E−3	0.17E−14	0.63E−4
24	0.20E−14	0.73E−4	0.12E−14	0.46E−4
25	0.59E−14	0.22E−3	0.14E−14	0.52E−4
26	0.38E−14	0.14E−3	0.11E−14	0.39E−4
27	0.30E−14	0.11E−3	0.13E−14	0.48E−4
28	0.38E−14	0.14E−3	0.19E−14	0.72E−4
29	0.22E−14	0.80E−4	0.16E−14	0.58E−4
30	0.22E−14	0.80E−4	0.11E−14	0.42E−4
31	0.25E−14	0.93E−4	0.15E−14	0.56E−4
32	0.38E−14	0.14E−3	0.11E−14	0.41E−4
33	0.24E−13	0.88E−3	0.14E−14	0.51E−4
34	0.51E−14	0.19E−3	0.13E−14	0.49E−4
35	0.28E−14	0.10E−3	0.13E−14	0.47E−4
36	0.28E−14	0.10E−3	0.11E−14	0.40E−4
37	0.20E−14	0.73E−4	0.15E−14	0.57E−4
38	0.33E−14	0.12E−3	0.15E−14	0.57E−4
39	0.31E−14	0.12E−3	0.13E−14	0.46E−4
40	0.24E−14	0.91E−4	0.11E−14	0.42E−4
41	0.24E−14	0.88E−4	0.13E−14	0.48E−4
42	0.24E−14	0.88E−4	0.11E−14	0.42E−4
43	0.15E−14	0.57E−4	0.13E−14	0.46E−4
44	0.33E−14	0.12E−3	0.15E−14	0.57E−4
45	0.26E−14	0.98E−4	0.11E−14	0.42E−4
46	0.33E−14	0.12E−3	0.14E−14	0.53E−4
47	0.30E−14	0.11E−3	0.10E−14	0.38E−4
48	0.28E−14	0.10E−3	0.11E−14	0.42E−4
49	0.18E−14	0.67E−4	0.12E−14	0.46E−4
50	0.26E−14	0.96E−4	0.17E−14	0.62E−4
51	0.27E−14	0.10E−3	0.14E−14	0.50E−4
52	0.26E−14	0.95E−4	0.13E−14	0.46E−4
Average	0.35E−14	0.13E−3	0.13E−14	0.47E−4

Table 4.8. Concentration of ^{131}I in air, 1981

Annual average by station

Station No.[a]	Location	Long-lived activity	
		μCi/cc	Bq/m^3
	Laboratory area		
HP-3	SW 1000	0.59E−14	0.22E−3
HP-4	W Settling Basin	0.22E−14	0.80E−4
HP-6	SW 3027	0.24E−14	0.90E−4
HP-7	W 7001	0.29E−14	0.11E−3
HP-8	Rock Quarry	0.27E−14	0.10E−3
HP-9	N Bethel Valley Road	0.32E−14	0.12E−3
HP-10	W 2075	0.94E−14	0.35E−3
HP-16	E 4500	0.20E−14	0.75E−4
HP-20	HFIR	0.26E−14	0.97E−4
HP-23	Walker Branch	0.13E−14	0.47E−4
Average		0.35E−14	0.13E−3
	Perimeter area		
HP-31	Kerr Hollow Gate	0.13E−14	0.46E−4
HP-32	Midway Gate	0.13E−14	0.48E−4
HP-33	Gallaher Gate	0.14E−14	0.52E−4
HP-34	White Oak Dam	0.13E−14	0.50E−4
HP-35	Blair Gate	0.13E−14	0.47E−4
HP-36	Turnpike Gate	0.12E−14	0.44E−4
HP-37	Hickory Creek Bend	0.12E−14	0.45E−4
HP-38	E EGCR	0.13E−14	0.47E−4
HP-39	Townsite	0.13E−14	0.48E−4
Average		0.13E−14	0.47E−4

[a]See Figs. 4.1–4.4 for station locations.

Table 4.9. Continuous air monitoring data, 1981

Specific radionuclides in air (composite samples) [μCi/cc $\times 10^{-15}$ (Bq/m$^3 \times 10^{-5}$)]

Radionuclide	Local stations				
	1st quarter	2nd quarter	3rd quarter	4th quarter	Yearly average
^{7}Be	46 (170)	59 (218)	77 (285)	40 (147)	56 (205)
^{54}Mn	0.29 (1.1)	1.5 (5.7)	0.14 (0.51)	0.050 (0.19)	0.51 (1.9)
^{90}Sr	0.095 (0.35)	1.0 (3.7)	0.50 (1.9)	0.25 (0.93)	0.46 (1.7)
^{95}Nb	38 (140)	69 (256)	4.0 (15)	0.33 (1.2)	28 (103)
^{95}Zr	19 (71)	34 (124)	1.7 (6.4)	0.17 (0.63)	14 (51)
^{103}Ru	11 (39)	23 (85)	0.27 (1.0)	0.042 (0.15)	8.5 (31)
^{106}Ru	6.7 (25)	9.0 (33)	4.0 (15)	0.21 (0.77)	5.0 (18)
^{125}Sb	0.90 (3.3)	2.5 (9.3)	0.25 (0.93)	0.14 (0.49)	0.95 (3.5)
^{137}Cs	1.0 (3.8)	4.4 (16)	0.86 (3.2)	0.40 (1.5)	1.7 (6.1)
^{141}Ce	5.0 (19)	50 (186)	0.13 (0.47)	0.063 (0.23)	13.9 (51)
^{144}Ce	11 (42)	4.6 (17)	6.3 (23)	1.2 (4.4)	5.8 (22)
^{228}Th	0.076 (0.28)	0.086 (0.32)	0.10 (0.38)	0.10 (0.37)	0.09 (0.34)
^{230}Th	0.053 (0.19)	0.050 (0.19)	0.032 (0.12)	0.065 (0.24)	0.05 (0.19)
^{232}Th	0.065 (0.24)	0.065 (0.24)	0.038 (0.14)	0.086 (0.32)	0.06 (0.24)
^{234}U	0.40 (1.5)	0.55 (2.0)	0.23 (0.85)	0.31 (1.2)	0.38 (1.4)
^{235}U	0.074 (0.27)	0.027 (0.10)	0.042 (0.16)	0.090 (0.33)	0.06 (0.22)
^{238}U	0.21 (0.78)	0.32 (1.2)	0.19 (0.69)	0.29 (1.1)	0.25 (0.94)
^{238}Pu	0.0013 (0.0047)	0.008 (0.003)	0.0006 (0.002)	0.10 (0.39)	0.03 (0.10)
^{239}Pu	0.023 (0.085)	0.035 (0.13)	0.011 (0.039)	0.003 (0.011)	0.02 (0.07)

Table 4.10. Continuous air monitoring data, 1981

Specific radionuclides in air (composite samples) [$\mu Ci/cc \times 10^{-15}$ ($Bq/m^3 \times 10^{-5}$)]

Radionuclide	Perimeter stations					Remote stations				
	1st quarter	2nd quarter	3rd quarter	4th quarter	Yearly average	1st quarter	2nd quarter	3rd quarter	4th quarter	Yearly average
^{7}Be	39 (144)	50 (185)	54 (200)	63 (232)	51 (190)	37 (136)	48 (178)	68 (252)	42 (157)	49 (181)
^{54}Mn	0.29 (1.1)	1.1 (4.1)	0.25 (0.94)	0.056 (0.21)	0.43 (1.59)	0.29 (1.1)	1.1 (4.1)	0.19 (0.70)	0.042 (0.16)	0.4 (1.5)
^{90}Sr	0.35 (1.3)	0.84 (3.1)	0.48 (1.8)	0.15 (0.56)	0.46 (1.69)	0.053 (0.20)	0.95 (3.5)	0.55 (2.0)	0.11 (0.41)	0.4 (1.5)
^{95}Nb	32 (119)	56 (205)	5.3 (19)	0.41 (1.5)	23 (86)	32 (119)	49 (183)	3.8 (14)	0.39 (1.4)	21 (79)
^{95}Zr	17 (61)	27 (100)	1.7 (6.1)	0.17 (0.63)	11 (42)	18 (68)	25 (93)	1.7 (6.1)	0.083 (0.31)	11 (42)
^{103}Ru	8.6 (32)	20 (72)	0.47 (1.7)	0.030 (0.11)	7.1 (26)	8.5 (31)	27 (100)	0.25 (0.93)	0.029 (0.11)	8.9 (33)
^{106}Ru	4.8 (18)	7.4 (27)	4.5 (17)	0.83 (3.1)	4.4 (16)	5.0 (19)	5.4 (20)	2.1 (7.9)	0.56 (2.1)	3.3 (12)
^{125}Sb	0.53 (1.9)	1.8 (6.7)	0.59 (2.2)	0.11 (0.41)	0.76 (2.8)	0.37 (1.4)	1.5 (5.5)	0.40 (1.5)	0.098 (0.36)	0.6 (2.2)
^{137}Cs	0.68 (2.5)	3.0 (11)	0.96 (3.6)	0.24 (0.89)	1.2 (4.5)	0.73 (2.7)	2.9 (11)	0.66 (2.4)	0.23 (0.86)	1.1 (4.2)
^{141}Ce	4.1 (15)	39 (144)	0.09 (0.33)	0.030 (0.11)	11 (40)	4.1 (15)	33 (121)	0.10 (0.36)	0.039 (0.14)	9.2 (34)
^{144}Ce	8.9 (33)	3.2 (12)	8.3 (31)	1.3 (4.9)	5.5 (20)	8.9 (33)	2.5 (9.3)	5.8 (21)	1.2 (4.5)	4.6 (17)
^{228}Th	0.035 (0.13)	0.036 (0.13)	0.069 (0.26)	0.051 (0.19)	0.05 (0.18)	0.027 (0.10)	0.033 (0.12)	0.077 (0.29)	0.035 (0.13)	0.04 (0.16)
^{230}Th	0.023 (0.083)	0.024 (0.089)	0.069 (0.26)	0.033 (0.12)	0.04 (0.14)	0.016 (0.058)	0.019 (0.071)	0.014 (0.051)	0.017 (0.063)	0.016 (0.06)
^{232}Th	0.023 (0.083)	0.027 (0.10)	0.026 (0.094)	0.041 (0.15)	0.03 (0.11)	0.016 (0.058)	0.021 (0.077)	0.016 (0.060)	0.021 (0.079)	0.019 (0.07)
^{234}U	0.42 (1.6)	0.45 (1.7)	0.26 (0.94)	0.47 (1.7)	0.40 (1.5)	0.091 (0.33)	0.061 (0.22)	0.046 (0.17)	0.060 (0.22)	0.06 (0.24)
^{235}U	0.051 (0.19)	0.009 (0.036)	0.038 (0.14)	0.071 (0.26)	0.04 (0.16)	0.017 (0.063)	0.0057 (0.021)	0.0076 (0.028)	0.007 (0.027)	0.01 (0.035)
^{238}U	0.23 (0.83)	0.35 (1.3)	0.18 (0.67)	0.35 (1.3)	0.28 (1.0)	0.063 (0.23)	0.049 (0.18)	0.032 (0.12)	0.042 (0.16)	0.05 (0.17)
^{238}Pu	0.0002 (0.0006)	0.0009 (0.003)	0.0003 (0.001)	0.0003 (0.001)	0.0004 (0.0014)	0.0008 (0.003)	0.0006 (0.002)	0.0002 (0.0006)	0.0008 (0.003)	0.0006 (0.002)
^{239}Pu	0.012 (0.044)	0.029 (0.11)	0.008 (0.032)	0.002 (0.007)	0.01 (0.05)	0.011 (0.042)	0.027 (0.10)	0.010 (0.038)	0.003 (0.011)	0.013 (0.05)

Table 4.11. Air monitoring data for suspended particulates, 1981

Location[a]	Number of samples	Concentration ($\mu g/m^3$) Maximum	Minimum	Annual geometric mean	Percentage of standard[b]
LAM-1	17	82	16	38	51
LAM-3	26	87	6	35	47
LAM-6	26	69	14	34	45
LAM-7	24	64	10	32	43
LAM-15	20	73	12	35	47

[a]See Fig. 4.1.
[b]Tennessee Air Pollution Control Regulations primary standard based on annual geometric mean is 75.0 $\mu g/m^3$.

Table 4.12. Concentration of ^{90}Sr in milk,[a] 1981

Station No.	Number of samples	Maximum		Minimum[b]		Average		Comparison with standards[c]
		pCi/L	mBq/L	pCi/L	mBq/L	pCi/L	mBq/L	
				Immediate environs[d]				
1	17	1.8	65	0.9	35	1.3 ± 0.13	47 ± 5	Range I
2	47	2.4	90	0.8	30	1.4 ± 0.11	52 ± 4	Range I
3	44	3.2	120	0.7	25	1.5 ± 0.14	56 ± 5	Range I
4	44	4.5	165	1.1	40	2.2 ± 0.24	81 ± 9	Range I
5	46	2.6	95	0.7	25	1.5 ± 0.12	57 ± 5	Range I
6	40	3.2	120	0.8	30	1.7 ± 0.18	62 ± 7	Range I
7	46	2.6	95	0.7	25	1.6 ± 0.11	60 ± 4	2.6
Average						1.6 ± 0.03	60 ± 1	
				Remote environs[e]				
51	6	2.4	90	0.7	25	1.5 ± 0.51	57 ± 19	Range I
52	3	1.3	50	1.1	40	1.2 ± 0.16	45 ± 6	Range I
53	3	0.9	35	0.5	20	0.8 ± 0.27	30 ± 10	Range I
56	7	1.6	60	0.7	25	1.0 ± 0.29	37 ± 11	Range I
58	4	2.2	80	1.1	40	1.7 ± 0.46	63 ± 17	Range I
Average						1.3 ± 0.22	47 ± 8	

[a]Raw milk samples, except for station 2, which is a dairy.
[b]Minimum detectable concentration of ^{90}Sr in milk is 0.5 pCi/L (19.0 mBq/L).
[c]Applicable FRC standard, assuming 1 L/d intake:

Range I:	0–20 pCi/L (0–740 mBq/L)	Adequate surveillance required to confirm calculated intakes
Range II:	20–200 pCi/L (740–7400 mBq/L)	Adequate surveillance required
Range III:	200–2000 pCi/L (7400–74,000 mBq/L)	Positive control action required

Note: Upper limit of range II can be considered the concentration guide.
[d]See Fig. 4.6.
[e]See Fig. 4.7.

Federal Radiation Council (FRC) range I. The concentrations of ^{90}Sr in milk from both the immediate and remote environs of ORNL are also within FRC range I.

4.3.7 ORNL Stack Releases

Radionuclide releases from ORNL stacks are summarized in Table 4.14.

Table 4.13. Concentration of ^{131}I in milk,[a] 1981

Station No.	Number of samples	Maximum		Minimum[b]		Average		Comparison with standards[c]
		pCi/L	mBq/L	pCi/L	mBq/L	pCi/L	mBq/L	
				Immediate environs[d]				
1	22	≤0.45	≤17	≤0.45	≤17	≤0.45 ± 0.00	≤17 ± 0	Range I
2	47	0.7	25	≤0.45	≤17	≤0.45 ± 0.01	≤17 ± 1	Range I
3	46	0.5	20	≤0.45	≤17	≤0.45 ± 0.01	≤17 ± 1	Range I
4	47	1.1	40	≤0.45	≤17	≤0.45 ± 0.03	≤17 ± 1	Range I
5	46	≤0.45	≤17	≤0.45	≤17	≤0.45 ± 0.01	≤17 ± 0	Range I
6	43	3.6	135	≤0.45	≤17	≤0.45 ± 0.15	≤17 ± 6	Range I
7	47	0.8	30	≤0.45	≤17	≤0.45 ± 0.02	≤17 ± 1	Range I
Average						≤0.45 ± 0.01	≤17 ± 0	
				Remote environs[e]				
51	6	≤0.45	≤17	≤0.45	≤17	≤0.45 ± 0.00	≤17 ± 0	Range I
52	3	≤0.45	≤17	≤0.45	≤17	≤0.45 ± 0.00	≤17 ± 0	Range I
53	3	0.5	20	≤0.45	≤17	≤0.45 ± 0.06	≤17 ± 2	Range I
56	7	≤0.45	≤17	≤0.45	≤17	≤0.45 ± 0.00	≤17 ± 0	Range I
58	4	1.3	50	≤0.45	≤17	≤0.45 ± 0.48	≤17 ± 8	Range I
Average						≤0.45 ± 0.10	≤17 ± 4	

[a]Raw milk samples, except for station 2, which is a dairy.
[b]Minimum detectable concentration of ^{90}Sr in milk is 0.5 pCi/L (19.0 mBq/L).
[c]Applicable FRC standard, assuming 1 L/d intake:

Range I:	0–10 pCi/L (0–370 mBq/L)	Adequate surveillance required to confirm calculated intakes
Range II:	10–100 pCi/L (370–8700 mBq/L)	Adequate surveillance required
Range III:	100–1000 pCi/L (3700–37,000 mBq/L)	Positive control action required

Note: Upper limit of range II can be considered the concentration guide.
[d]See Fig. 4.6.
[e]See Fig. 4.7.

Table 4.14. Annual discharges of radionuclides to the atmosphere

Stack No.	^{3}H		^{85}Kr		^{131}I		^{133}Xe		Unidentified alpha	
	kCi	TBq	kCi	TBq	Ci	GBq	kCi	TBq	MCi	kBq
2026					≤0.12	4.4				
3020					≤0.12	4.4				
3039	9.8	361	5.1	188	≤0.12	4.4	24.7	910		
7025	1.5	55								
7911			1.6	59	≤0.12	4.4	7.7	284		
Trans Lab									≤0.04	1.5
4508									≤0.04	1.5
Total	11.3	416	6.7	247	≤0.48	17.6	32.4	1194	≤0.08	3.0

4.4 WATER MONITORING

4.4.1 White Oak Lake Waters

Yearly discharges of specific radionuclides into the Clinch River from 1969 through 1981 are shown in Table 4.15. Table 4.16 gives values for radionuclide concentrations at various locations in the

Table 4.15. Annual discharges of radionuclides to the Clinch River

Discharges expressed in curies[a]

	Year	^{137}Cs	^{106}Ru	^{90}Sr	Transuranic alpha	^{3}H
	1969	1.4	1.7	3.1	0.2	12,200
	1970	2.0	1.2	3.9	0.4	9,500
	1971	0.93	0.50	3.4	0.05	8,900
	1972	1.7	0.52	6.5	0.05	10,600
	1973	2.3	0.69	6.7	0.08	15,000
	1974	1.2	0.22	6.0	0.02	8,600
	1975	0.62	0.30	7.2	0.02	11,000
	1976	0.24	0.16	4.5	0.01	7,400
	1977	0.21	0.20	2.7	0.03	6,250
	1978	0.27	0.21	2.0	0.03	6,292
	1979	0.24	0.13	2.4	0.03	7,700
2.16	1980	0.62	0	1.5	0.04	4,554
1.87	1981	0.23	0.10	1.5	0.04	2,876

[a]To convert to tera-Becquerels, multiply curies by 0.037.

Clinch River. The calculated percentages of concentration guides in water (CG_w) are presented in Table 4.17.

For 1969 through 1981, the annual average percentage CG_w of beta emitters other than tritium in the Clinch River is given in Table 4.18. Table 4.19 lists the annual average percentage CG_w of tritium in the Clinch River for the same time period.

Trends in radionuclide discharges and CG_w levels are presented in Figs. 4.9–4.11. Discharges of ^{3}H and ^{90}Sr are shown in Fig. 4.9; these nuclides contribute the majority of the radiological dose downstream.

Water samples for the analysis of nonradioactive substances are collected at the same locations as those for radioactive water sampling. All samples are composited from monthly analyses. Samples are analyzed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the EPA.

Data on chemical concentrations in surface streams are given in Tables 4.20 and 4.21. Table 4.22 shows percentages of water quality compliance with the National Pollutant Discharge Elimination System (NPDES).

4.4.2 Potable Water

The average quarterly concentrations of ^{90}Sr in potable water at ORNL during 1981 were:

Quarter No.	μCi/mL	Bq/L
1	0.54E−9	0.20E−1
2	0.49E−9	0.18E−1
3	0.13E−8	0.47E−1
4	0.38E−8	0.14
Average	0.15E−8	0.56E−1

The average value of 1.5E−8 μCi/mL (0.56E−1 Bq/L) represents 0.5% of the CG_w for drinking water applicable to individuals in the general population.

Table 4.16. Radionuclides in the Clinch River, 1981

Location	Number of samples	Range	Concentration of radionuclides of primary concern [10^{-9} μCi/mL (Bq/L)]					Percentage CG[b]
			^{90}Sr	^{137}Cs	^{106}Ru	^{60}Co	^{3}H[a]	
C-2, CRM 23.1 (Melton Hill)	4	Max	2.703 (0.100)	0.108 (0.004)	0.027 (0.001)	0.541 (0.020)	3730 (138.0)	
		Min	0.541 (0.020)	0.054 (0.002)	≤0.027 (≤0.001)	0.054 (0.002)	≤135 (≤5.0)	
		Av	1.304 (0.048)	0.074 (0.003)	≤0.027 (≤0.001)	0.203 (0.008)	≤1415 (≤52.0)	0.48
C-3, CRM 14.5 (Gallaher)	4	Max	2.973 (0.110)	0.216 (0.008)	0.027 (0.001)	0.135 (0.005)	3622 (134.0)	
		Min	0.270 (0.010)	0.027 (0.001)	≤0.027 (≤0.001)	0.054 (0.002)	≤138 (≤5.0)	
		Av	1.439 (0.053)	0.115 (0.004)	≤0.027 (≤0.001)	0.095 (0.004)	≤1641 (≤61.0)	0.54
C-5, TRM 568 (Kingston Water Plant)	4	Max	5.406 (0.200)	0.189 (0.007)	0.027 (0.001)	0.216 (0.008)	2027 (75.0)	
		Min	0.541 (0.020)	0.054 (0.002)	≤0.027 (≤0.001)	0.081 (0.003)	≤676 (≤25.0)	
		Av	3.108 (0.115)	0.135 (0.005)	≤0.027 (≤0.001)	0.155 (0.006)	≤1198 (≤44.0)	1.08
W-1, CRM 20.8 (Mouth of White Oak Creek)	12	Max	116 (4.29)	43.3 (1.60)	16.2 (0.599)	91.9 (3.40)	≤1,080,000 (40,000)	
		Min	17.6 (0.651)	1.7 (0.63)	0.81 (0.30)	10.8 (0.399)	16,000 (600)	
		Av	61.9 (2.29)	10.0 (0.37)	3.3 (0.122)	32.9 (1.22)	203,000 (7,500)	27.5

[a]Three tritium samples.

[b]The most restrictive concentration guide for each isotope is used to calculate the percentage concentration guide. The method for calculating the percentage of concentration guide for a known mixture of radionuclides is given in DOE Order 5480.1, Chap. XI.

Table 4.17. Calculated percentage CG_w of ORNL liquid radioactivity releases at three locations, 1981

Month	White Oak Dam	Intersection of White Oak Creek and Clinch River	Calculated value for Clinch River[a]
January	107	25	0.2
February	122	50	1.2
March	89	42	1.3
April	94	45	1.4
May	90	16	1.1
June	125	62	0.6
July	72	12	0.1
August	59	18	0.1
September	75	13	0.1
October	85	6	0.2
November	115	8	0.3
December	134	31	0.6
Average	97	27	0.6

[a]Values at White Oak Dam divided by dilution of Clinch River.

Table 4.18. Annual average percentage CG_w of beta emitters, other than tritium, in the Clinch River[a]

Year	CRM 23.1[b]	Calculated value for Clinch River[c]	CRM 14.5[b]	CRM 4.5[b]
1969	0.30	0.36	0.48	0.41
1970	0.22	0.27	0.53	0.47
1971	0.21	0.20	0.65	0.44
1972	0.18	0.26	0.58	0.48
1973	0.24	0.49	0.47	0.62
1974	0.06	0.36	0.26	0.21
1975	0.03	0.43	0.14	0.12
1976	0.05	0.44	0.23	0.15
1977	0.05	0.21	0.07	0.10
1978	0.04	0.20	0.06	0.05
1979	0.03	0.20	0.06	0.02
1980	0.04	0.18	0.27	0.43
1981	0.43	0.52	0.48	1.0

[a]Values are predominantly from ^{90}Sr.
[b]Values given for this location are based on analyses of water taken directly from the river.
[c]Values given for this location are calculated from the levels of radionuclides released from White Oak Dam and dilution provided by the Clinch River.

Table 4.19. Annual average percentage CG_w of tritium in the Clinch River

Year	CRM 20.8[a]
1969	0.11
1970	0.05
1971	0.04
1972	0.04
1973	0.07
1974	0.04
1975	0.06
1976	0.07
1977	0.05
1978	0.05
1979	0.04
1980	0.03
1981	0.08

[a] Values given are calculated from the level of waste released from White Oak Dam and dilution provided by the Clinch River.

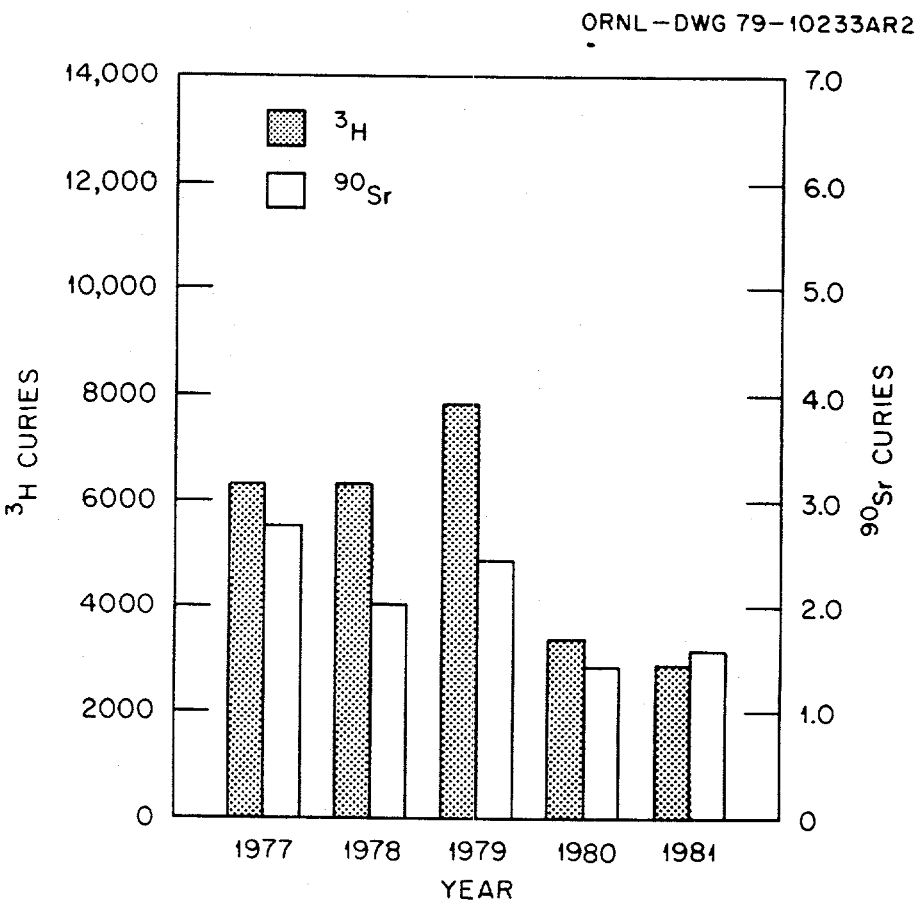

Fig. 4.9 Radioactivity (Ci) discharged over White Oak Dam.

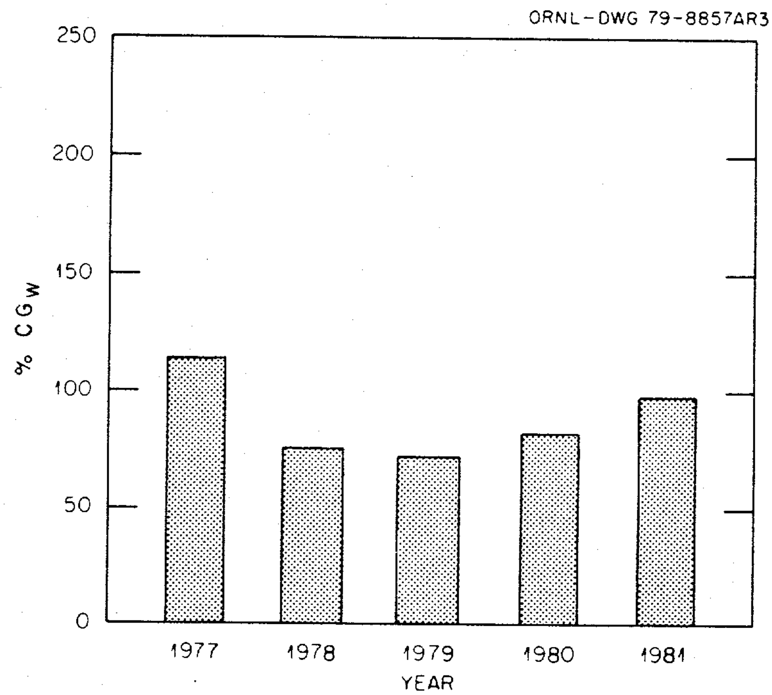

Fig. 4.10. Total CG_w levels discharged over White Oak Dam.

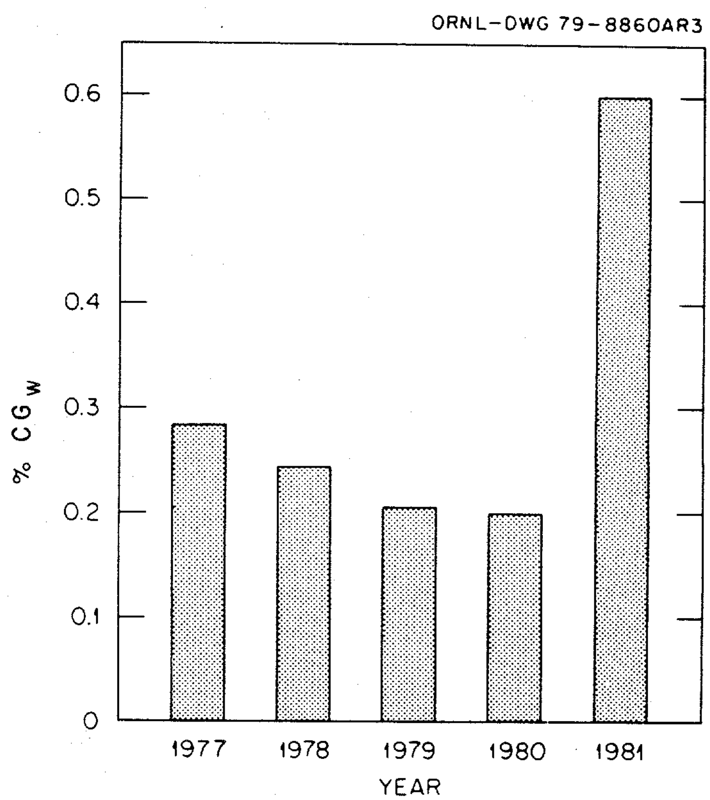

Fig. 4.11. Total CG_w levels in the Clinch River.

Table 4.20. Chemical water quality data from White Oak Dam,[a] 1981

Substance	Number of samples	Concentration (mg/L) Maximum	Minimum	Average	STD[b]	Percentage STD[b]
Cr	4	≤0.005	≤0.005	≤0.005	0.05	≤10
Zn	5	≤0.02	≤0.02	≤0.02	0.1	≤20
NO_3(N)	5	8.3	3.6	6.1 ± 1.7	10	61
Hg	5	≤0.002	≤0.001	≤0.001	0.005	≤20

[a]Samples taken from location W-1 (see Fig. 4.5).
[b]Tennessee Stream Guidelines.

Table 4.21. Chemical water quality data from Melton Hill Dam,[a] 1981

Substance	Number of samples	Concentration (mg/L) Maximum	Minimum	Average	STD	Percentage STD[b]
Cr	4	≤0.005	≤0.005	≤0.005	0.05	≤10
Zn	5	≤0.02	≤0.02	≤0.02	0.1	≤20
NO_3(N)	5	0.98	0.63	0.8 ± 0.1	10	≤10
Hg	6	≤0.001	≤0.001	≤0.001	0.005	≤20

[a]Samples taken from location C-2 (see Fig. 4.5).
[b]Tennessee Stream Guidelines.

4.4.3 Clinch River Fish

Results of the analyses of fish samples are tabulated in pCi/kg (Bq/kg) of wet weight (Table 4.23) for each radionuclide of significance. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 37 lb (16.8 kg). An estimated percentage of maximum permissible intake is calculated by assuming a maximum permissible intake of fish to be comparable to a daily intake of 2.2 L of water containing the MPC_w of these radionuclides for a period of one year. Mercury concentrations were compared with the FDA proposed action level.

4.5 RADIATION BACKGROUND MEASUREMENTS

Data on average external gamma radiation background rates are given in Tables 4.24 and 4.25. The difference between the average levels in the perimeter and the remote environs is considered to be within the variation in background levels normally experienced in eastern Tennessee, which is dependent on elevation, topography, and the geological character of the surrounding soil.[2]

Average external gamma radiation levels along the banks of the Clinch River adjacent to an experimental cesium field are given in Table 4.26.

2. T. W. Oakes, K. E. Shank, and C. E. Easterly, "Natural and Man-Made Radionuclide Concentrations in Tennessee Soil," pp. 322–333 *in Proceedings of the Health Physics Society Tenth Midyear Topical Symposium, Saratoga Springs, New York, October 11–13, 1976.*

Table 4.22. National Pollutant Discharge Elimination System (NPDES) experience, 1981

Discharge point	Effluent parameters	Effluent limits (mg/L)		Percentage of measurements in compliance
		Daily average	Daily maximum	
ORNL				
001	Dissolved oxygen, min	5		100
(White Oak Creek)	Dissolved solids		2000	92
	Oil and grease	10	15	92
	Chromium, total		0.05	98
	pH		6.0–9.0	99
002	Chromium, total		0.05	100
(Melton Branch)	Dissolved solids		2000	100
	Oil and grease	10	15	100
	pH		6.0–9.0	99
003	Ammonia, N		5	17
(main sanitary	BOD		20	60
treatment facility)	Chlorine residual		0.5–2.0	93
	Fecal coliform bacteria, No./100 mL	200[a]	400[b]	100
	pH		6.0–9.0	100
	Suspended solids		30	100
	Settleable solids, mL/L		0.5	94
004	BOD		30	No discharges from this facility
(7900 area sanitary	Chlorine residual		0.5–2.0	
treatment facility)	Fecal coliform bacteria, No./100 mL	200[a]	400[b]	
	pH		6.0–9.0	
	Suspended solids		30	
	Settleable solids, mL/L		0.5	

[a] Monthly average.
[b] Weekly average.

4.6 SOIL AND GRASS SAMPLES

Data on uranium, plutonium, and other radioisotope concentrations in soil and grass samples are given in Tables 4.27 and 4.28.

4.7 DEER SAMPLES

Occasionally, deer are killed by automobiles on the DOE Reservation. Thirty-nine road-killed deer were analyzed during 1981 for gamma emitters, and the data are presented in Table 4.29. Note that hunting is illegal on the reservation.

4.8 CALCULATION OF POTENTIAL RADIATION DOSE TO THE PUBLIC

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations. The site boundary for the Oak Ridge complex was defined as the perimeter of the DOE-controlled area.

Gaseous effluents are discharged from several locations within ORNL. For our calculations, the gaseous discharges were assumed to occur from only one vent. Concentrations of radionuclides contained

Table 4.23. Radionuclide content in Clinch River fish, 1981

pCi/kg (Bq/kg) wet weight

Clinch River mile	Species[a]	^{90}Sr	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{137}Cs	^{60}Co	^{40}K	MPI[b] (%)	Hg (ng/g)	Action level[c] (%)
5.0	Bass	3.7 (0.14)	0.011 (0.0004)	0.0076 (0.0003)	0.26 (0.010)	0.14 (0.005)	0.26 (0.009)	98.3 (3.6)	3.78 (0.14)	3780 (140)	0.04	133	27
	Blue gill	6.5 (0.24)	0.0081 (0.0003)	0.057 (0.0021)	0.77 (0.029)	0.41 (0.015)	1.82 (0.068)	72.9 (2.7)	4.05 (0.15)	3524 (131)	0.05	86	17
	Carp	18.3 (0.68)	0.011 (0.0004)	0.011 (0.0004)	2.21 (0.082)	0.81 (0.030)	15.8 (0.59)	77.2 (2.9)	3.86 (0.14)	3335 (124)	0.14	289	58
	Shad	24.3 (0.90)	0.014 (0.0005)	0.014 (0.0005)	7.80 (0.29)	1.61 (0.059)	11.9 (0.44)	119 (4.4)	6.89 (0.26)	2984 (111)	0.18	73	15
	Crappie	8.1 (0.30)	0.011 (0.0004)	0.0070 (0.0003)	0.27 (0.010)	0.12 (0.004)	0.53 (0.019)	98.3 (3.6)	3.51 (0.13)	3510 (130)	0.07	401	80
10.0	Bass	3.8 (0.14)	0.011 (0.0004)	0.011 (0.0004)	0.25 (0.009)	0.16 (0.006)	0.68 (0.025)	106 (3.9)	1.51 (0.056)	3440 (127)	0.04	237	47
	Blue gill	8.9 (0.33)	0.032 (0.0012)	0.041 (0.0015)	12.2 (0.45)	2.15 (0.080)	19.8 (0.74)	56.7 (2.1)	3.24 (0.12)	3200 (119)	0.07	257	51
	Carp	26.7 (0.99)	0.011 (0.0004)	0.012 (0.0004)	1.02 (0.038)	0.67 (0.025)	2.32 (0.086)	63.2 (2.3)	3.51 (0.13)	3861 (143)	0.19	487	97
	Shad	14.7 (0.54)	0.10 (0.0037)	0.023 (0.0009)	4.41 (0.16)	1.56 (0.058)	6.89 (0.26)	119 (4.4)	5.97 (0.22)	3259 (121)	0.12	44	9
	Crappie	3.9 (0.14)	0.014 (0.0005)	0.0018 (0.00007)	0.27 (0.010)	0.25 (0.009)	1.02 (0.038)	70.2 (2.6)	2.11 (0.078)	3264 (121)	0.03	131	26
12.0	Bass	4.5 (0.17)	0.011 (0.0004)	0.0038 (0.0001)	0.29 (0.011)	0.026 (0.0009)	0.49 (0.018)	215 (8.0)	2.27 (0.084)	3742 (138)	0.05	43	9
	Blue gill	6.9 (0.26)	0.081 (0.003)	0.10 (0.0038)	3.24 (0.12)	2.23 (0.083)	13.8 (0.51)	72.9 (2.7)	8.10 (0.30)	4455 (165)	0.05	18	4
	Carp	4.6 (0.17)	0.025 (0.0009)	0.018 (0.0007)	0.28 (0.011)	0.066 (0.0025)	0.42 (0.016)	25.9 (0.96)	2.11 (0.078)	3510 (130)	0.03	575	115
	Shad	3.8 (0.14)	0.064 (0.0024)	0.0092 (0.0003)	5.51 (0.20)	0.50 (0.019)	8.72 (0.32)	96.4 (3.6)	4.59 (0.17)	4452 (165)	0.03	23	5
	Crappie	4.6 (0.17)	0.020 (0.0007)	0.0070 (0.0002)	0.98 (0.036)	0.17 (0.0062)	1.44 (0.053)	98.2 (3.6)	1.76 (0.065)	0	0.04	102	20
20.8[d]	Bass	27.6 (1.0)	0.026 (0.001)	0.011 (0.0004)	0.79 (0.029)	0.23 (0.009)	1.78 (0.066)	878 (33)	140 (0.52)	3534 (131)	0.29	144	29
	Blue gill	172.5 (6.4)	0.028 (0.001)	0.053 (0.002)	0.69 (0.026)	0.38 (0.014)	1.94 (0.072)	1371 (51)	51.0 (1.89)	3868 (143)	1.35	117	23
	Carp	52.3 (1.9)	0.014 (0.0005)	0.021 (0.0008)	0.46 (0.017)	0.28 (0.010)	1.12 (0.042)	270 (10)	27.4 (1.01)	3029 (112)	0.39	108	22
	Shad	32.6 (1.2)	0.17 (0.006)	0.073 (0.003)	3.72 (0.14)	0.50 (0.019)	5.92 (0.22)	693 (26)	53.2 (1.97)	3709 (137)	0.30	44	9
	Crappie	34.1 (1.3)	0.007 (0.0003)	0.007 (0.0003)	0.46 (0.017)	0.11 (0.004)	1.12 (0.042)	770 (29)	9.48 (0.35)	3744 (139)	0.32	253	51
25.0	Bass	4.54 (0.17)	0.019 (0.0007)	0.008 (0.0003)	0.95 (0.035)	0.42 (0.015)	1.51 (0.056)	10.6 (0.39)	3.78 (0.14)	4158 (154)	0.03	16	3
	Blue gill	17.8 (0.66)	0.008 (0.0003)	0.012 (0.0005)	1.17 (0.044)	0.89 (0.033)	3.16 (0.12)	12.6 (0.47)	2.43 (0.09)	2309 (86)	0.13	57	11
	Carp	56.2 (2.08)	0.007 (0.0003)	0.007 (0.0003)	1.44 (0.053)	0.42 (0.016)	5.62 (0.21)	3.51 (0.13)	3.51 (0.13)	3299 (122)	0.39	124	25
	Shad	8.26 (0.31)	0.005 (0.0002)	0.007 (0.0003)	0.69 (0.026)	0.60 (0.022)	0.78 (0.029)	5.05 (0.19)	4.59 (0.17)	3259 (121)	0.06	12	2
	Crappie	3.51 (0.13)	0.007 (0.0003)	0.007 (0.0003)	1.82 (0.068)	0.56 (0.021)	2.56 (0.095)	10.9 (0.40)	3.51 (0.13)	2984 (111)	0.03	30	6

[a]Composite of 10 fish in each species.
[b]Maximum permissible intake = intake of radionuclide from eating fish calculated to be equal to a daily intake of 2.2 L of water over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 16.8 kg/year of the species in question. Only man-made radionuclides were used in the calculation.
[c]Percentage of proposed FDA mercury in fish action level of 500 ng/g; mercury data are included in this table as a matter of convenience.
[d]Average of quarterly samples.

Table 4.24. External gamma radiation measurements at local air monitoring stations, 1981

Station No.	μrad/h	μGy/h[a]	mrad/year	mGy/year[b]
HP-1	24	0.24	207	2.07
HP-2	67	0.67	588	5.88
HP-3	10	0.10	86	0.86
HP-4	140	1.40	1228	12.3
HP-5	33	0.33	290	2.90
HP-6	38	0.38	331	3.31
HP-7	8	0.08	68	0.68
HP-8	8	0.08	65	0.65
HP-9	10	0.10	86	0.86
HP-10	12	0.12	109	1.09
HP-11	10	0.10	91	0.91
HP-12	50	0.50	436	4.36
HP-13	137	1.37	1198	12.0
HP-14	11	0.11	98	0.98
HP-15	11	0.11	92	0.92
HP-16	9	0.09	78	0.78
HP-17	11	0.11	92	0.92
HP-18	8	0.08	69	0.69
HP-19	11	0.11	100	1.00
HP-20	11	0.11	97	0.97
HP-21	9	0.09	76	0.76
HP-22	13	0.13	113	1.13
Average	29	0.29	254	2.54

[a]Average of two samples.
[b]Calculated assuming that an individual remained at this point for 24 h/day for the entire year.

Table 4.25. External gamma radiation measurements, 1981

Station No.	Location	Number of measurements	Background	
			μrad/h (μGy/h)	mrad/year (mGy/year)
		Perimeter[a]		
HP-31	Kerr Hollow Gate	12	9.7 (0.097)	85 (0.85)
HP-32	Midway Gate	12	11.7 (0.117)	102 (1.02)
HP-33	Gallaher Gate	12	9.7 (0.097)	85 (0.85)
HP-34	White Oak Dam	12	17.8 (0.178)	156 (1.56)
HP-35	Blair Gate	12	8.5 (0.085)	74 (0.74)
HP-36	Turnpike Gate	12	8.1 (0.081)	71 (0.71)
HP-37	Hickory Creek Bend	12	7.9 (0.079)	69 (0.69)
HP-38	East of EGCR	12	8.5 (0.085)	74 (0.74)
HP-39	Townsite	12	9.0 (0.090)	79 (0.79)
Average			10.1 (0.101)	88 (0.88)
		Remote[b]		
HP-51	Norris Dam	2	5.8 (0.058)	51 (0.51)
HP-52	Loudon Dam	2	7.3 (0.073)	64 (0.64)
HP-53	Douglas Dam	2	7.7 (0.077)	67 (0.67)
HP-55	Watts Bar Dam	2	6.5 (0.065)	57 (0.57)
HP-56	Great Falls Dam	2	7.3 (0.073)	64 (0.64)
HP-57	Dale Hollow Dam	2	7.7 (0.077)	67 (0.67)
HP-58	Knoxville	2	10.9 (0.109)	95 (0.95)
Average			7.6 (0.076)	67 (0.67)

[a]See Fig. 4.3.
[b]See Fig. 4.4.

Table 4.26. External gamma radiation measurements along the perimeter of the DOE–Oak Ridge controlled area, 1981

Station No.[a]	μrad/h	μGy/h	mrad/year[b]	mGy/year
HP-60	11.5	0.12	100.7	1.01
HP-61	15.8	0.16	138.4	1.38
HP-62	36.7	0.37	321.5	3.22
HP-63	68.4	0.68	599.2	5.99
HP-64	32.0	0.32	280.3	2.80
HP-65	31.9	0.32	279.4	2.79
HP-66	31.6	0.32	276.8	2.77
HP-67	20.7	0.21	181.3	1.81
HP-68	12.8	0.13	112.1	1.12
HP-69	10.5	0.11	91.9	0.92

[a]See Fig. 4.8 for station location.

[b]Calculated assuming that an individual remained at this point for the entire year.

in the air and deposited on the ground were estimated at distances up to 50 miles (80 km) from the Oak Ridge facilities, using the Gaussian plume model developed by Pasquill[3] and Gifford[4] incorporated into the computer program AIRDOS.[5] The concentration was averaged over the crosswind direction to give the estimated ground-level concentration downwind of the source of emission. The deposition velocities used in the calculations were 0.0 cm/s for krypton and xenon, 0.2 cm/s for iodine, and 0.1 cm/s for particulates. Meteorological data are shown in Fig. 4.12; the lengths of the bars indicate the percentage of time that the wind was blowing in that direction. Populations used are shown in Table 4.30.

Exposures to radionuclides originating in effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals by using models and data presented in publications of the International Commission on Radiological Protection, other recognized literature on radiation protection, personal communications, and computer programs incorporating some of these models and data. Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by the processes of metabolism and radioactive decay; thus, the estimates for internal dose are called "dose commitments." They are obtained by integration over an assumed working lifetime of 50 years for the exposed individual.

Radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal; however, doses to individual organs may vary considerably because some radionuclides concentrate in certain organs. For this reason, in estimating radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract, various pathways of exposure were considered. These estimates were based on parameters applicable to an average adult. The population dose estimate (in person-rem) is the sum of the total-body doses to exposed individuals within a 50-mile (80-km) radius of the Oak Ridge facilities.

4.8.1 Maximum potential exposure

The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the banks of the Clinch River adjacent to a cesium field experimental plot and is due primarily to sky

3. F. Pasquill, *Atmospheric Diffusion*, D. Van Nostrand Co., Ltd., London, 1962.
4. F. A. Gifford, Jr., *The Problem of Forecasting Dispersion in the Lower Atmosphere*, USAEC, DTI, 1962.
5. R. E. Moore et al., *AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides*, EPA 520/1-79-009, 1979.

Table 4.27. Radioactivity in soil samples from perimeter and remote monitoring stations, 1981

pCi/g (Bq/kg) dry weight

Station No.[a]	^{7}Be	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}Pu	^{239}Pu	^{238}U	^{226}Ra	^{232}Th	^{95}Nb	^{95}Zr
						Perimeter[b]						
HP-31		0.3 (11)	1.0 (37)	0.7 (26)	0.05 (1.9)	0.012 (0.4)	0.03 (1.1)	0.3 (11)	0.9 (33)	1.1 (41)		
HP-32	0.2 (7)	0.2 (7)	1.1 (41)	1.3 (48)	0.03 (1.1)	0.002 (0.07)	0.03 (1.1)	0.9 (33)	0.9 (33)	0.9 (33)		
HP-33		0.4 (15)	1.1 (41)	0.4 (15)	0.02 (0.7)	0.002 (0.07)	0.04 (1.5)	0.2 (7)	0.8 (30)	0.9 (33)	0.05 (1.9)	
HP-34		0.5 (19)	1.5 (56)	0.3 (11)	0.02 (0.7)	0.002 (0.07)	0.03 (1.1)	0.3 (11)	0.9 (33)	1.3 (48)	0.06 (2.2)	
HP-35		0.4 (15)	1.7 (63)	0.5 (19)	0.03 (1.1)	0.003 (0.1)	0.04 (1.5)	0.4 (15)	0.8 (30)	0.7 (26)	0.1 (3.7)	
HP-36	0.3 (11)	0.2 (7)	1.4 (52)	0.5 (19)	0.03 (1.1)	0.004 (0.2)	0.02 (0.7)	0.3 (11)	0.8 (30)	0.8 (30)	0.07 (2.6)	
HP-37	1.3 (48)	0.7 (26)	0.8 (30)	0.2 (7)	0.02 (0.7)	0.004 (0.2)	0.04 (1.5)	0.3 (11)	0.5 (19)	0.5 (19)	0.9 (33)	0.4 (15)
HP-38	1.3 (48)	0.6 (22)	0.9 (33)	0.3 (11)	0.02 (0.7)	0.003 (0.1)	0.04 (1.5)	0.2 (7)	0.7 (26)	0.7 (26)	0.8 (30)	0.3 (11)
HP-39	0.4 (15)	0.2 (7)	2.3 (85)	0.9 (33)	0.06 (2.2)	0.004 (0.2)	0.06 (2.2)	0.9 (33)	0.8 (30)	0.8 (30)	0.4 (15)	0.06 (2.2)
Average	0.7 (26)	0.4 (14)	1.3 (49)	0.6 (21)	0.03 (1.1)	0.004 (0.1)	0.04 (1.5)	0.4 (15)	0.8 (30)	0.9 (33)	0.3 (11)	0.25 (9.3)
						Remote[c]						
HP-51		0.3 (11)	0.5 (19)	0.4 (15)	0.04 (1.5)	0.002 (0.07)	0.02 (0.7)	0.4 (15)				
HP-52		0.2 (7)	1.0 (37)	0.5 (19)	0.03 (1.1)	0.007 (0.26)	0.08 (3)	0.3 (11)				
HP-53		0.3 (11)	1.9 (70)	0.9 (33)	0.04 (1.5)	0.008 (0.30)	0.19 (7)	0.7 (26)				
HP-55		0.1 (4)	1.4 (52)	0.6 (22)	0.04 (1.5)	0.002 (0.07)	0.05 (2)	0.5 (19)				
HP-56		0.2 (7)	0.8 (30)	0.7 (26)	0.05 (2)	0.007 (0.26)	0.09 (3)	0.6 (22)				
HP-57		0.3 (11)	3.5 (130)	0.5 (19)	0.03 (1.1)	0.001 (0.04)	0.06 (2)	0.4 (15)				
HP-58		0.1 (4)	0.8 (30)	0.3 (11)	0.01 (0.4)	0.005 (0.19)	0.04 (1)	0.3 (11)				
Average		0.2 (7)	1.4 (52)	0.6 (22)	0.03 (1.1)	0.004 (0.2)	0.08 (2.7)	0.5 (19)				

[a]See Figs. 4.3 and 4.4 for station location.
[b]Average of two samples.
[c]One sample.

Table 4.28. Radioactivity in grass samples from perimeter and remote monitoring stations, 1981

pCi/g (Bq/kg) dry weight

Station No.[a]	^{7}Be	^{90}Sr	^{137}Cs	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{144}Ce[d]	^{95}Nb[b]
					Perimeter[e]					
HP-31	0.89 (33)	0.38 (14)	0.18 (6.7)	0.0089 (0.331)	0.0018 (0.065)	0.09 (3.5)	0.015 (0.54)	0.17 (6.3)	2.3 (84)	0.86 (32)
HP-32	0.52 (19)	0.43 (16)	0.07 (2.6)	0.0008 (0.029)	0.0004 (0.015)	0.11 (3.9)	0.021 (0.78)	0.39 (14)	0.93 (35)	0.26 (9.8)
HP-33	0.50 (20)	0.47 (18)	0.10 (3.6)	0.0022 (0.088)	0.0007 (0.028)	0.04 (1.5)	0.005 (0.20)	0.07 (2.7)	1.3 (46)	0.51 (19)
HP-34	0.29 (12)	0.57 (21)	0.08 (2.9)	0.0010 (0.035)	0.0011 (0.040)	0.03 (1.1)	0.010 (0.38)	0.07 (2.7)	0.55 (20)	0.26 (9.8)
HP-35	0.27 (10)	0.47 (18)	0.06 (2.1)	0.0017 (0.063)	0.0008 (0.031)	0.05 (1.9)	0.014 (0.51)	0.12 (4.3)	0.62 (23)	NA
HP-36	0.41 (15)	0.82 (31)	0.04 (1.5)	0.0008 (0.034)	0.0007 (0.028)	0.03 (1.1)	0.010 (0.38)	0.05 (2.0)	0.52 (19)	0.65 (24)
HP-37	0.89 (33)	0.55 (21)	0.15 (5.5)	0.0005 (0.018)	0.0007 (0.028)	0.02 (0.8)	0.006 (0.23)	0.05 (2.0)	1.3 (48)	0.62 (23)
HP-38	1.34 (51)	0.49 (18)	0.35 (13.0)	0.0014 (0.050)	0.0009 (0.036)	0.03 (1.1)	0.007 (0.25)	0.05 (2.0)	3.0 (112)	1.4 (52)
HP-39	0.70 (26)	0.62 (23)	0.15 (5.6)	0.0026 (0.075)	0.0018 (0.068)	0.08 (3.0)	0.071 (2.6)	0.16 (5.9)	1.4 (50)	0.26 (9.6)
Average	0.7 (25)	0.58 (21)	0.13 (4.8)	0.0023 (0.077)	0.0011 (0.054)	0.08 (2.9)	0.020 (0.75)	0.16 (5.7)	1.3 (49)	0.61 (22)
					Remote[d]					
HP-51	3.7 (140)	0.95 (35)	0.09 (3.3)	0.0049 (0.18)	0.0005 (0.02)	0.032 (1.2)	0.018 (0.67)	0.062 (2.3)	0.96 (35)	1.8 (66)
HP-52	10 (380)	0.76 (28)	0.13 (5.0)	0.0002 (0.01)	0.0049 (0.18)	0.059 (2.2)	0.054 (2.0)	0.17 (6.2)	2.1 (78)	3.4 (125)
HP-53	0.9 (33)	0.95 (35)	0.08 (3.1)	0.0002 (0.01)	0.0022 (0.08)	0.027 (1.0)	0.013 (0.48)	0.049 (1.8)	2.3 (85)	3.0 (109)
HP-55	NA[c]	0.59 (22)	NA	0.0001 (≤0.01)	≤0.0001 (≤0.01)	0.026 (0.95)	0.025 (0.92)	0.070 (2.6)	NA	NA
HP-56	NA	0.62 (23)	NA	0.0041 (0.15)	0.0002 (0.01)	0.095 (3.5)	0.013 (0.47)	0.076 (2.8)	NA	NA
HP-57	4.5 (170)	0.38 (14)		0.0014 (0.05)	0.0002 (0.01)	0.011 (0.42)	0.003 (0.11)	0.025 (0.9)	NA	NA
HP-58	NA	0.54 (20)	0.06 (2.4)	0.0014 (0.05)	0.0008 (0.03)	0.024 (0.87)	0.017 (0.62)	0.068 (2.5)	1.0 (38)	1.8 (66)
Average	4.8 (180)	0.68 (25)	0.09 (3.4)	0.0018 (0.06)	0.0017 (0.06)	0.039 (1.5)	0.020 (0.75)	0.074 (2.7)	1.6 (59)	2.5 (91)

[a]See Figs. 4.3 and 4.4 for station location.
[b]These data indicate weapons test fallout.
[c]Average of two samples.
[d]One sample.
[e]NA = not available.

Table 4.29. ^{137}Cs concentration in deer samples, 1981

Wet weight

Sample No.	Muscle		Liver	
	pCi/g	Bq/kg	pCi/g	Bq/kg
D-1	0.078	2.9	*a*	*a*
D-2P	*a*	*a*	*a*	*a*
D-3	*a*	*a*	*a*	*a*
D-4	0.027	1.0	0.059	2.2
D-5	0.062	2.3	0.049	1.8
D-6	0.032	1.2		*a*
D-7	0.035	1.3		*a*
D-8P	0.016	0.6		*a*
D-9	0.027	1.0		
D-10	0.030	1.1		
D-11	0.024	0.9		NA[b]
D-12	*a*	*a*	0.030	1.1
D-13	0.041	1.5		*a*
D-14	0.027	1.0		*a*
D-16	0.92	34	0.38	14.0
D-17	0.032	1.2		*a*
BL-1	0.11	4.2		*a*
BL-2		*a*		*a*
D-22	0.045	1.8	0.019	0.7
D-23[d]	0.016	0.6	0.014	0.5
D-24	0.070	2.6	0.043	1.6
D-25	0.16	6.0	0.051	1.9
D-26	0.15	5.6	0.059	2.2
D-27	0.95	35.0	0.22	8.2
D-28	0.35	13.0	0.17	6.2
D-29	0.62	23.0	0.14	5.2
D-30	0.17	6.3	0.15	5.5
D-31	0.19	7.1	0.084	3.1
D-32	0.086	3.2	0.054	2.0
D-33	0.27	10.0	0.65	24.0
D-34		NA	0.059	2.2
D-35[e]	0.20	7.5	0.065	2.4
D-36	0.25	9.1	0.12	4.4
D-37	0.057	2.1	0.016	0.6
D-38	0.14	5.1	0.059	2.2
D-39	0.19	7.0	0.068	2.5
D-41	0.20	7.3	0.043	1.6
D-42	0.095	3.5	0.076	2.8
D-43	0.27	10.0		
D-44	0.14	5.1	0.051	1.9
D-45	0.11	4.2	0.027	1.0
D-46	0.073	2.7		

[a] Entries indicate a concentration level <0.01 pCi/g (<0.4 Bq/kg).

[b] NA = not available.

[c] Also 0.005 pCi/g (0.2 Bq/kg) ^{60}Co in muscle; 0.2 pCi/g (7.5 Bq/kg) ^{60}Co in liver.

[d] Also 0.02 pCi/g (0.7 Bq/kg) ^{60}Co in muscle.

[e] Also 0.01 pCi/g (0.5 Bq/kg) ^{60}Co in muscle.

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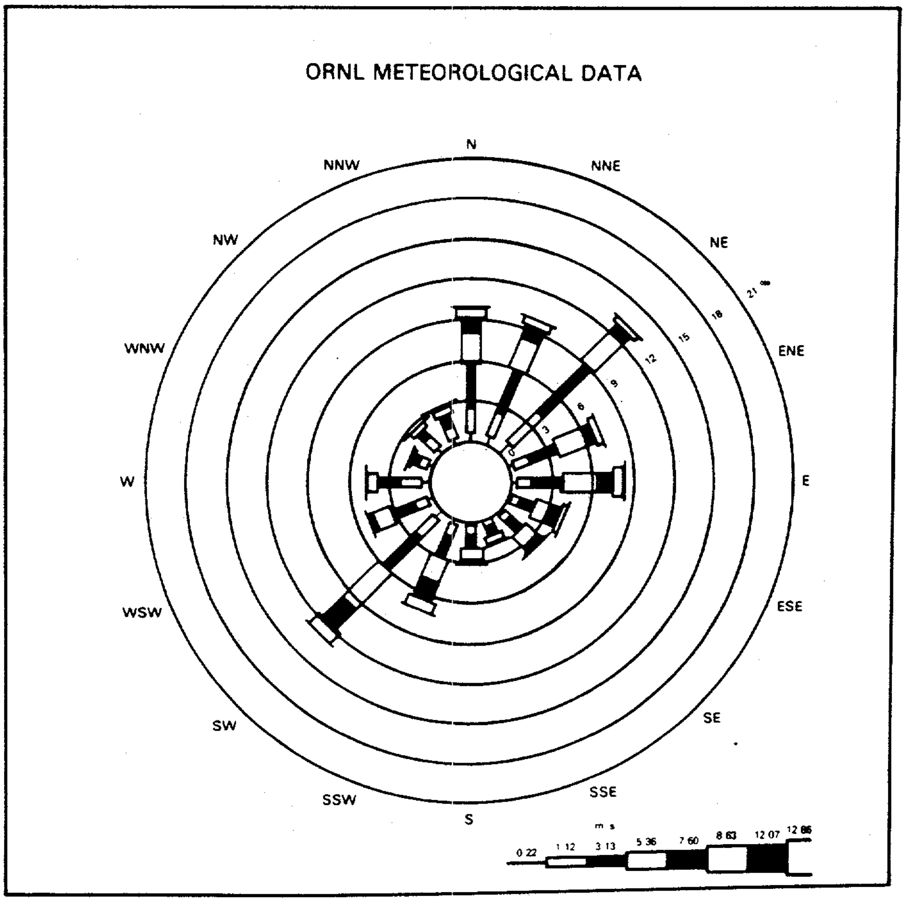

Fig. 4.12. Meteorological data for the Oak Ridge Reservation.

shine from the plot. A maximum potential whole-body dose of 215 mrem/year (2.2 mSv/year) was calculated for this location, assuming that an individual remained at this point for 24 h/d for the entire year. The calculated maximum potential exposure is 43% of the allowable standard.[1] This is an atypical exposure location, and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total-body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 h/year. The calculated dose under these conditions was 5.9 mrem/year (0.06 mSv/year), which is 1.1% of the allowable standard and represents what is considered a probable upper limit of exposure. A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and ingestion; an inhalation rate of 2E4 L/d for the average adult is used. Calculated dose commitments at this location were 9.2 mrem (0.09 mSv) ± 300% to the lung (the critical organ) and 0.38 mrem (0.004 mSv) ± 300% to the total body; ^{234}U is the important radionuclide contributing to this dose. These levels are 0.61 and 0.076%, respectively, of the allowable annual standard. The large error bounds result from uncertainties in the meteorological and source-term data.

Table 4.30. Incremental population table in the vicinity of ORNL

Given at distance from site [miles (km)]

Direction	0–1 (0–1.6)	1–2 (1.6–3.2)	2–3 (3.2–4.8)	3–4 (4.8–6.4)	4–5 (6.4–8.0)	5–10 (8–16)	10–20 (16–32)	20–30 (32–48)	30–40 (48–64)	40–50 (64–80)
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
Total	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
Cumulative total	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

The most important contribution to dose from radioactivity within the food chain comes from the atmosphere-pasture-cow-milk pathway. Measurements of the two principal radionuclides entering this pathway, ^{90}Sr and ^{131}I (see Tables 4.12 and 4.13), indicate that the maximum dose to an individual in the immediate environs from ingestion of 1 L/d of milk is 0.02 mrem (0.0002 mSv) to the thyroid and 2.7 mrem (0.03 mSv) to the bone at station 6 (see Fig. 4.6). Average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located about 26 km (16 miles) downstream at Kingston. Measurements of untreated river water samples at Kingston (see Table 4.16) indicate that the maximum dose commitment resulting from the ingestion of 20% of the daily adult requirement (about 2 L/d) is 10.9 mrem (0.11 mSv) to the bone and 0.22 mrem (0.002 mSv) to the whole body. Average concentrations for Melton Hill water (background) were subtracted from the values obtained at Kingston.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 37 lb (16.8 kg) of fish per year from the Clinch River. This amount is about 2.5 times the national average fish consumption and is used because of the popularity of fishing in eastern Tennessee. From the analysis of edible parts of the fish examined (see Table 4.23), the maximum organ dose commitment to an individual from the bluegill samples taken from CRM 20.8 is estimated to be 71 mrem (0.71 mSv) to the bone from ^{90}Sr. The maximum total-body dose to an individual was calculated to be 2.9 mrem (0.03 mSv) from ^{137}Cs. These doses are 5 and 0.6%, respectively, of the allowable standard. Fish samples taken from above White Oak Creek were analyzed to determine background conditions.

If fish bones were consumed, projected dose commitments would be higher than those shown in this report. Strontium concentrates in the bone, and preliminary test results indicate that the dose commitment from eating 1 kg of fish with bone would be greater by a factor of 3–30 than that from eating 1 kg of boneless fish. This possibility is of interest because commercial fishermen may catch carp, which is then processed into fish patties that include the bone. The study will be continued (1) to determine more accurately the increase of the dose commitment that would result from the inclusion of bone and (2) to determine the amount, if any, of commercially processed carp taken from the Clinch River near and below the discharge of White Oak Creek.

Summaries are given in Table 4.31 of the potential radiation doses to adults in the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

4.8.2 Dose to the population

The Oak Ridge population received the largest average individual total-body dose as a population group. The average yearly total-body dose to an Oak Ridge resident was estimated to be 0.092 mrem (0.0009 mSv), compared with about 100 mrem (1 mSv) from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.55 mrem (0.006 mSv). The maximum potential dose commitment to an Oak Ridge resident was calculated to be 9.2 mrem (0.092 mSv) to the lung. This calculated dose is 0.61% of the allowable annual standard.

The cumulative total-body dose to the population within a 50-mile (80-km) radius of the Oak Ridge facilities resulting from 1981 plant effluents was calculated to be 31.5 person-rems (0.32 person-mSv). This dose may be compared with an estimated 87,000 person-rems to the same population

Table 4.31. Summary of the estimated radiation dose to an adult individual during 1981 at locations of maximum exposure

Pathway	Location	Dose [mrem (μSv)] Total body[a]		Organ	
Gaseous effluents					
Inhalation plus direct radiation from air and ground	Nearest resident to site boundary	0.38	(3.8)	9.2	(92) (lung)
Terrestrial food chains	Milk sampling stations (^{90}Sr)	0.02	(0.2)	2.7	(27) (bone)
Liquid effluents					
Aquatic food chains	Clinch–Tennessee River system (^{90}Sr)	2.9	(29)	71	(710) (bone)
Drinking water[b]	Kingston, Tenn. (^{90}Sr)	0.22	(2.2)	10.9	(109) (bone)
Direct radiation along water, shores, and mud flats[c]	Downstream from White Oak Creek near experimental cesium field plots	5.9	(59)	5.9	(59) (total body)

[a]Average background total-body dose in the United States is 106 mrem/year.
[b]Based on the analysis of raw (unprocessed) water.
[c]Assuming a residence time of 240 h/year.

resulting from natural background radiation. About 7.6% of the collective dose from the effluents of the Oak Ridge facilities is estimated to be absorbed by the Oak Ridge population.

4.9 HIGHLIGHTS OF OTHER MAJOR ACTIVITIES OF THE ENVIRONMENTAL MANAGEMENT PROGRAM

4.9.1 Environmental Protection Awards

Environmental Protection Awards were established by the ORNL Environmental Coordinator's Office to recognize outstanding achievements in environmental protection by ORNL employees outside the IS&AHP Division. Winners are selected on the basis of the scientific and technical merit of the achievement, potential cost savings for the Laboratory, and innovation. The Analytical Chemistry Division and ten of its staff members were named recipients of the first Environmental Protection Awards. Analytical Chemistry Division Director Wilbur D. Shults accepted the division award presented for "developments in analytical techniques for determining analytical contaminants."

Individual honorees included Joseph H. Stewart, Jr., for "liaison and coordination of specific environmental analysis problems"; Harris W. Dunn, Robert L. Sherman, and Stewart for "the development of a system for quantitative determinations of asbestos in construction materials"; Hershel G. Davis and Robert R. Rickard for "development of a procedure for the analysis of PCBs in oil"; James S. Eldridge, Tommy G. Scott, and James R. Stokely, Jr., for "developments in the detection of radioactivity in environmental samples"; and Bruce R. Clark and William F. Rogers for "the development of the ORNL oil characterization program."

4.9.2 Waste Oil Investigation Committee

Repeated occurrences of improper discharges of oil at ORNL resulted in the formation of the ORNL Waste Oil Investigation Committee on March 14, 1979. The committee has completed its investigation, and a report is in progress.

4.9.3 ORNL Committee of Meteorological Data Users

During 1981, the committee continued to play an important role in the development of a meteorological tower system for ORNL. This work included selection of the three tower sites (two 30 m and one 100 m), review of design documentation, and coordination of ORNL's system with those proposed or installed at the other two Oak Ridge installations. Based on this work, a contractor (Environmental Systems Corporation) has begun the installation of ORNL's system as a 1981 General Plant Project (GPP), which should be completed by December 1982.

4.9.4 Hazardous Waste Analysis Laboratory

Currently, more than 400 hazardous chemicals or wastes, either from specific sources or as discarded hazardous chemicals, are listed by the EPA under the Resource Conservation and Recovery Act. Many waste streams generated at ORNL have not yet been characterized. For these types of wastes, EPA regulations currently require testing of specific parameters (e.g., ignitability, corrosivity, reactivity, and toxicity) to determine if the waste must be treated as hazardous.

During 1981, over 700 analyses were performed by personnel in the Analytical Chemistry Division. The analyses included flash point, reactivity, corrosivity determinations, extractable portion (EP) toxic analysis of leachate materials, and PCB and organic solvent analysis of waste oils.

4.9.5 Chemical Waste Disposal

During 1981, about 420 disposal requests were handled by the Hazardous Materials Management Group of the Department of Environmental Management (DEM). These disposal requests represent 88,314 lb (40,143 kg) of hazardous wastes generated at ORNL. By using approved offsite commercial facilities for disposal, ORNL was able to comply with existing regulations.

4.9.6 Soil and Sediment Contamination Analysis

In 1981, the DEM conducted two projects that involved determining the distribution of radionuclides in soil and sediment samples.

Soil core samples were collected from the vicinity of Building 3505 (Metal Recovery Building) and were analyzed for ^{137}Cs and ^{60}Co. One area was found to contain as much as 4.6E4 pCi/g (1.7E6 Bq/kg) ^{137}Cs. Samples from this area were also analyzed for ^{90}Sr, ^{235}U, ^{238}U, ^{239}Pu, and ^{241}Am. The data have been reviewed, and additional samples may be necessary to make a full assessment. A report on this project is in progress.

Sediment samples were collected from Waste Retention Pond 3524, and the radionuclide analysis indicated the presence of ^{239}Pu, ^{241}Am, ^{244}Cm, ^{137}Cs, ^{60}Co, ^{90}Sr, and ^{154}Eu in these sediments. The data are being evaluated, and a report is in progress.

4.9.7 Air Monitoring Station Replacement

The DEM continued its program to modernize the air monitoring system. Efforts during 1981 included additional software development and hardware additions to the experimental Air Monitoring Station and the purchase of a surplus PDP 11/40 computer to act as the data collection system for all new monitors. This computer will also be linked to the Meteorological Tower System computer when it is installed.

4.9.8 ORNL Steam Plant Stack Testing

During 1981, the DEM coordinated the stack compliance test for ORNL's Steam Plant. The plant met all appropriate state and EPA standards and is currently in routine operation.

4.9.9 Environmental Assessments

Environmental assessments for 29 projects were completed during 1981. The following is a list of the projects:

Accelerator and Reactor Improvement Project (EN-Tandem)
Accelerator and Reactor Improvement Project (HHIF)
Additions to the Process Waste Treatment System
Coal Combustor for Cogeneration
Consolidated Fuel Reprocessing Program—Hot Engineering Facility
Contaminated Oil Storage Facility
Cooling Water Facilities Restoration
Core Storage/Examination Facility
Decommissioning of ILW Transfer Line
Energy Systems Research Laboratory
Gas Cylinder Storage Facility
Hazardous Waste Incinerator Facility
High-Temperature Materials Laboratory
Improvements to Fusion Energy Facilities
Improvements to White Oak Avenue
Interim Decontamination Facility
Laboratory Emergency Response Center
Metal Waste Volume Reduction Facility
Meteorological Towers
Modernize Laboratories for the Study of Environmental Pollutants
Modify Building 3019's Off-Gas System
Mutagenic Screening and Testing Facility for Synthetic Fuels
Repaint Tower Shielding Facility
Replace Steam Lines, 5500 Area
Superconducting ORIC Conversion
Toxic Substances Laboratory and Animal Facility
Upgrade Electrical Service for Research Facilities at Y-12
Water Pollution Control, Phase I
West Addition, Building 2026

4.9.10 New and Improved Facilities

Work was completed on a storage facility for spent photographic processing solutions and on improvements to the waste-oil storage area. The DEM is continuing work on two projects: installation of a continuous residual chlorine analyzer at ORNL's Sewage Treatment Plant and construction of a treatment system for coal yard runoff. The DEM began work on three new projects: installation of a sulfur dioxide analyzer at LAM station 7, design and construction of a meteorological tower system for

ORNL (1981 GPP), and design of a new hazardous waste storage facility (1982 GPP). Work continued on two proposed line-item projects: water pollution control, phase I, and environmental and effluent monitoring systems replacement.

4.9.11 Computerized Data Processing

The effort to computerize environmental data in the DEM continued. A program for computerized handling of information on the quality of wastewater discharges at three ORNL monitoring stations has been designed and implemented. This computer system analyzes field and laboratory data and calculates water quality statistics appropriate for meeting NPDES reporting requirements. The program was designed for ease of editing and expanding if the ORNL NPDES permit is modified in the future.

The DEM is working on automatic transfer of data from the Analytical Chemistry Division for reporting chemical and radionuclide analyses to individual program report areas. This system is in the testing and design stages and is scheduled for completion in 1982.

Several programs and data base files were created for special projects in 1981. These programs will be utilized as project requirements increase the necessity of computer use.

4.9.12 Hazardous Materials Tracking System

The DEM, in cooperation with Computer Sciences Division personnel, is developing a Hazardous Materials Tracking System (HMTS) designed to track hazardous materials at ORNL from receipt or generation to use and storage in the Laboratory to disposal. Software development is almost complete, and an information file containing pertinent data plans for initiated procedural changes is being formulated. The system is to be tested during 1982.

4.9.13 Bar-Code Reader System

A system that uses a bar-code reader for following the location and status of environmental samples was developed. The bar-code reader system is similar to those used in grocery stores. The system will provide for bar-code entry of parameters such as sample number, sample type, location, and technician's initials. The reader should reduce the amount of labor required for sample accounting and help reduce the number of data errors. Computer software is being developed for the reader system, and field testing should take place in 1982.

4.9.14 *ORNL Environmental and Safety Report*

The NUS Corporation prepared the *ORNL Environmental and Safety Report* during 1981. This document will be used as the source document for an environmental analysis of Laboratory operations to be written in 1982.

4.9.15 Radiological Assessment of Radioactive Waste Disposal Areas

Results of 1979 and 1980 thermoluminescent dosimeter (TLD) surveys of the solid waste disposal areas were compiled in ORNL/TM-7962.[6] TLD data for PAM and RAM stations are included for comparison.

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6. T. W. Oakes et al., *Radiological Assessment of Radioactive Waste Disposal Areas at Oak Ridge National Laboratory*, ORNL/TM-7962, December 1981.

4.9.16 Solid Waste Storage Area Monitoring Program

In 1981, DEM monitored on a quarterly basis 100 wells located in solid waste storage areas 4, 5, and 6 and selected waste trenches. This program includes field measurements and radionuclide analyses. A written report should be completed in 1982.

4.9.17 Water Quality

In 1981, DEM conducted a wastewater characterization study in compliance with the DOE-ORO request. The initial report was completed and submitted to DOE-ORO for consideration for EPA draft NPDES permits for ORNL. The purpose of the study was to identify and quantify discharges from internal wastewater discharges. Fifteen sites meeting the specified requirements of EPA were monitored from July through December 1981. Water samples were collected, prepared, and analyzed to meet the EPA requirements as specified in 40 CFR 122.53(d). The parameters included field data (dissolved oxygen, pH, and temperature), asbestos, volatile organics, oil and grease, solids (total suspended and settleable), chemical oxygen demand, cyanide, phenol, biochemical oxygen demand, total organic carbon, polychlorinated biphenyls, endrin, chlordane, ammonia, nitrate, total Kjeldahl nitrogen, total phosphorus, polynuclear aromatic hydrocarbons, and metals (Al, Ag, As, Be, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Sr, Tl, U, and Zn). The results are under further review. A technical manual is being prepared and is expected to be completed in 1982, pending EPA's review of the initial report.

4.9.18 Foodstuff Project

Food samples obtained from commercial markets and local farmers were analyzed for stable elements (e.g., Ag, Al, Ba, Cd, Co, Fe, Hf, Mn, Na, Ni, Pb, Zn, and Zr). The concentrations of most elements were determined using multiple-element neutron activation analysis; atomic absorption techniques were used to determine the concentrations of other elements.

The foodstuff project has been completed, the concentrations of elements found in the food samples have been compared with values in the literature, and a report[7] has been published on part of the project. A second report is in preparation.

4.9.19 Special Projects for Analysis of Radionuclide Pathways to Man

To determine and analyze possible radionuclide pathways to man, several programs were conducted in 1981 by the Surveillance Group of DEM. These programs are continuing and include investigations of pathways to man from aquatic insects, honeybees, and deer. Several species of aquatic insects were collected from the contaminated hydrofracture pond and were analyzed for gamma-emitting radionuclides by using high-resolution gamma-ray spectrometry. Water, algae, and sediment from the pond were also analyzed. Adult dragonflies collected from emergence traps contained about 1.1E5 pCi/g (4.0E6 Bq/kg) of ^{137}Cs and 2.7E2 pCi/g (1.0E4 Bq/kg) of ^{60}Co. Studies of mosquitoes reared in a solution of ^{65}Zn and ^{131}I were also conducted. Preliminary results indicate that these isotopes were transmitted to white mice when they were bitten by the mosquitoes. Honeybees were also studied to determine the effect of contaminated areas on the concentrations of tritium in the bees and honey. Honey from contaminated areas had a significantly higher concentration of tritium than did honey from control areas. Also during 1981, liver and muscle tissue from about 40 road-killed deer were analyzed

7. M. A. Montford et al., "Elemental Concentrations in Food Products," pp. 155–164 in *Proceedings of University of Missouri's 14th Annual Conference on Trace Substances in Environmental Health, Columbia, Missouri, June 2–5, 1980.*

for ^{137}Cs and ^{60}Co. The ^{137}Cs concentration in muscle from different deer varied from below the detection limit to a high of 945 pCi/kg (35 Bq/kg) on a fresh-weight basis.

4.9.20 Department of Environmental Management Office at Y-12

Effective February 1, 1981, DEM assumed responsibility for the environmental protection of ORNL facilities at Y-12, and at that time a field office was established in Building 9200 to coordinate activities.

The office is responsible for hazardous waste disposal, air emission permits, approval of discharges into drains, environmental assessments, laboratory inspection, and review of engineering documentation. The office is not responsible for the Y-12 NPDES program or for responding to emergencies.

Accomplishments during CY 1981 are listed in the following:

1. Meetings were held with Environmental Protection Officers and their division management representing the following Y-12 ORNL facilities: Analytical Chemistry, Biology, Operations, Computer Sciences, Engineering Technology, Information, IS&AHP, and Engineering Physics divisions.
2. Twenty-three laboratory inspections were completed.
3. All transformers were located and inspected.
4. All furnaces and ovens were located and inspected, and air emission permits were requested where required.
5. All welding stations were located, and air emission permits are being obtained.
6. Building 9732-4, located at the southwest corner of 9204-1, was decommissioned and removed because of thorium contamination.
7. About 2600 lb (1179 kg) of Resource Conservation and Recovery Act (RCRA) waste and 1200 lb (544 kg) of PCB-contaminated waste were shipped to ORNL for offsite disposal.

4.9.21 Phenol Degradation by Continuous dc Electrolysis

A study to determine the nature of phenol degradation by continuous dc electrolysis was conducted in collaboration with the University of Missouri to explore the development of new methods for treating hazardous and toxic wastes. Preliminary results indicate that dc electrolysis can result in low-energy production of free radicals capable of oxidizing phenol to CO_2 and H_2O, but that the production rate and secondary utilization of free radicals are limited. New methods of radical production are being considered.

4.9.22 Manuals

The manual *Methods and Procedures Utilized in Environmental Management Activities at Oak Ridge National Laboratory* is being updated; changes will be sent to those on the distribution list as they are completed.

To comply with changing federal and state regulations and to standardize the format, all existing environmental protection procedures were rewritten and issued on August 1, 1981. The approved procedures are:

1.0 Asbestos
2.0 Oils (Non-PCB)

3.0 Mercury
4.0 Polychlorinated Biphenyls
5.0 Cooling Tower Sludge
6.0 Substantial Risk Notification Under the Toxic Substances Control Act
7.0 Environmental Protection Officers
8.0 Disposal Procedures for Old Unwanted Chemicals (Nonradioactive)
9.0 Air Emission Permits
10.0 Environmental Assessments

In addition, two new procedures are currently being reviewed. These procedures are 11.0—Prudent Practices for Secondary Containment (Dikes) for Hazardous Materials and 12.0—Prudent Practices for Storage of Nonradioactive Hazardous Chemicals in Laboratories.

4.9.23 Water and Air Discharge Monitoring

In April 1981, the DEM environmental monitoring program was expanded to include monitoring at the points where material is discharged into waterways (pipe discharges) or to the atmosphere (stack discharges).

Water samples from flow proportional composite samplers include:

East Weir
West Weir
Flume (Station 2)
Melton Branch Station 4 (MB-4)
Melton Branch Station 2 (MB-2)
Manhole 190D Sampling Station
White Oak Creek (WOC) Station 3
7500 Bridge
Homogeneous Reactor Test Pond (HRT)
Process Waste Treatment Plant

Water samples of batch releases include the following locations:

HFIR Process Waste Pond
TRU Process Waste Pond

Samples from all locations are analyzed weekly and monthly for ^{90}Sr, gross alpha, and gross beta. In addition, gamma spectrometry is performed weekly and monthly on samples from:

HFIR Process Waste Pond
Manhole 190D Sampling Station
TRU Process Waste Pond
Process Waste Treatment Plant

A monthly composite sample is obtained from the Sewage Treatment Plant and is analyzed for ^{90}Sr, gross alpha, gross beta, and gamma spectrum.

Stack discharge samples consist of large and small charcoal cartridges that are analyzed for ^{131}I. Corresponding to each small charcoal cartridge is an air particulate filter, which is analyzed immediately for gross alpha and gross beta and is analyzed 8 d later for longer-lived alpha- and beta-emitting isotopes. Stack discharge samples are submitted three times a week for stack 3039 and once a week for the remaining stacks.

4.9.24 White Oak Basin Stream Survey

A water sampling survey of the White Oak Lake watershed was conducted in May 1981. Two hundred eighty-five locations were sampled, and analyses were done for ^{90}Sr by the Cerenkov method and for ^{3}H by liquid scintillation counting. One creek [draining solid waste dispoal area (SWSA) 5] is being monitored monthly as a result of this survey. Results are being compared with earlier ones, and a report is being prepared.

5. Safety Department

5.1 INDUSTRIAL SAFETY AND SPECIAL PROJECTS

The Industrial Safety and Special Projects Section is responsible for developing and implementing accident prevention and loss management programs within the Laboratory. The staff provides consultation and assistance in industrial safety matters and participates in inspection and evaluation programs to assess the level of safety of various ORNL activities. The staff participates in a variety of safety-related activities, including developing safety policies and procedures, reviewing engineering drawings for safety content, and providing safety orientation and specialized safety education programs. They maintain a library of DOE-prescribed safety standards, safety reference material, and audiovisual aids. The section also provides Laboratory-wide on- and off-the-job safety promotion activities. The staff is involved in investigating, analyzing, classifying, and documenting injuries and accidental property losses. The safety staff also provides support to ORNL's Construction Engineering Section in carrying out the construction safety program.

The section is responsible for assisting management in the formulation and direction of the Laboratory's safety program and for helping to develop and maintain a high level of safety awareness among all Laboratory employees through a program consistent with UCC-ND and UCC safety policies.

To fulfill these objectives, the staff assists the management line organization and Laboratory personnel in all areas relating to personnel safety and accident prevention. A principal function is to help Laboratory division representatives in the development of action plans to adequately meet their safety requirements. Included in the action plans are the routine activities normally associated with a successful safety program: (1) conducting safety meetings and safety inspections; (2) investigating, analyzing, and reporting on all accidents and near-misses; (3) formulating and issuing policies, guides, procedures, and standards; (4) providing education and training services; (5) conducting periodic safety performance appraisals; (6) seeking to improve off-the-job safety performance; and (7) preparing records and reports. The staff performs evaluations of the Laboratory divisions' safety performance in these seven categories on a quarterly basis.

The ORNL Off-the-Job Safety Action Plan was developed to reduce the number of off-the-job injuries. Off-the-job injuries result in huge monetary loss to the Laboratory, as well as pain to the injured. Effort will continue to obtain the best off-the-job safety material possible (visual and written), as well as to discuss off-the-job safety subjects in safety meetings.

Presentation of education and training programs by Industrial Safety Section staff has always been recognized as an important part of the safety effort at the Laboratory. Defensive driving, hazard potential recognition, supervisor development program, and orientation for new employees are some of the programs now under way.

5.1.1 CY 1981 Summary

The continuing emphasis on safety during CY 1981 resulted in significant improvements in the ORNL safety program. Through the combined efforts of all employees, ORNL safety performance was better than all CY 1981 on-the-job injury and illness goals, as shown in the following:

	Lost-work-day cases		Recordable injuries and illnesses	
	Number	Incidence rate	Number	Incidence rate
1981 (actual)	0	0.00	41	0.95
1981 (goal)	2	0.04	45	1.00

Through December 31, 1981, the Laboratory had worked 600 days and accumulated 14,015,826 exposure-hours since the last lost-work-day case.

The off-the-job safety program was expanded in CY 1981. More safety meetings were devoted to the subject, using films purchased from outside sources, internally created videotapes, and talks about personal experiences. Additionally, information on off-the-job accident prevention continued to be distributed to employees as handouts in safety meetings and through direct mailing to employees' homes. These efforts enabled the Laboratory to better its CY 1981 goal, as shown in the following:

	Off-the-job disabling injuries	Off-the-job frequency rate
1981 (actual)	60	3.29
1981 (goal)	68	3.53

The Laboratory earned the following awards for safety performance in 1981:

1. UCC Silver Award for Outstanding Safety Performance for operating 12,000,000 employee-hours without a lost-work-day case from May 11, 1980, through October 6, 1981.
2. UCC Bronze Award for Outstanding Safety Performance for operating 8,000,000 employee-hours without a lost-work-day case from May 11, 1980, through April 13, 1981.
3. National Safety Council Award of Honor for the seventh consecutive year (NSC's highest award). For 1981, ORNL also had the best record among research and development laboratories, according to NSC.
4. First Place in the National Safety Council's Chemical Section Safety Contest, Group 1.
5. DOE Award of Achievement for maintaining the incidence rate of lost work days and restricted work cases below 1.0 for four consecutive years.
6. DOE-ORO Outstanding Safety Performance Award for operating through CY 1981 without a case involving days away from work.

Each employee at the Laboratory accumulated $31.50 in the Safety Incentive Award Plan for their safety performance in CY 1981.

Representatives of DOE or UCC-ND's Office of Health, Safety, and Environmental Affairs conducted three separate audits or inspections of the Industrial Safety Section. The results were:

1. UCC-ND Safety and Health Audit, conducted February 9–13, 1981, recognized ORNL for administering effective and innovative safety and health programs consistent with UCC, DOE, Nuclear

Division, and Laboratory requirements, with several procedural exceptions for which corrective action was immediately initiated.

2. DOE Industrial and Construction Safety Appraisal, conducted September 28 and 29 and October 5–7 and 13, 1981, resulted in a superior rating.
3. DOE Occupational Safety and Health Inspection, conducted October 1, 1981, resulted in an assessment of no conditions posing imminent danger. Five violations identified during the inspection were posted and immediate corrective actions initiated.

ORNL employees contributed to UCC-ND's accomplishment of obtaining the lowest lost-work-day case incidence rate in its history. Employees throughout the Laboratory have demonstrated a very positive attitude toward safety; with this type of continued attitude and effort, it is unlikely that we will reach or exceed our control limits for 1982.

5.1.2 Accident Analysis

Injury statistics for ORNL for 1971–1981 are shown in Tables 5.1 and 5.2. The formulas for determining lost-work-day statistics are reported in ANSI Z16.4.[1] Ten ORNL divisions did not have a recordable injury or illness (RII) in 1981; incident rates by division are shown in Fig. 5.1. Figure 5.2 breaks down ORNL injury data by the part of the body injured. Table 5.3 presents a summary of medical treatment cases.

Table 5.1. Statistics on disabling injuries at ORNL, 1971–1981

	Number	Days lost	Employee-hours ($\times 10^6$)	Frequency rate[a]	Severity rate[a]
1971	4	1944	6.513	0.61	298
1972	7	377	6.467	1.08	52
1973	2	692	6.020	0.33	115
1974	5	315	6.183	0.81	52
1975	2	173	7.304	0.27	24
1976	1	106	7.644	0.13	14
1977	1	70	8.017	0.12	9

[a]Number per 1,000,000 h of exposure.

Table 5.2. Statistics on lost-work-day cases at ORNL, 1978–1981

	Number	Days lost	Employee-hours ($\times 10^6$)	Incidence rate[a]	Lost-work-day incidence rate[a]
1978	3	55	8.448	0.07	1.30
1979	3	77	8.401	0.07	1.83
1980	2	147	8.512	0.05	3.45
1981	0	0	8.610	0.00	0.00

[a]Number per 200,000 h of exposure.

1. "American National Standard for Uniform Record Keeping for Occupational Injuries and Illnesses," ANSI Z16.4, New York, 1977.

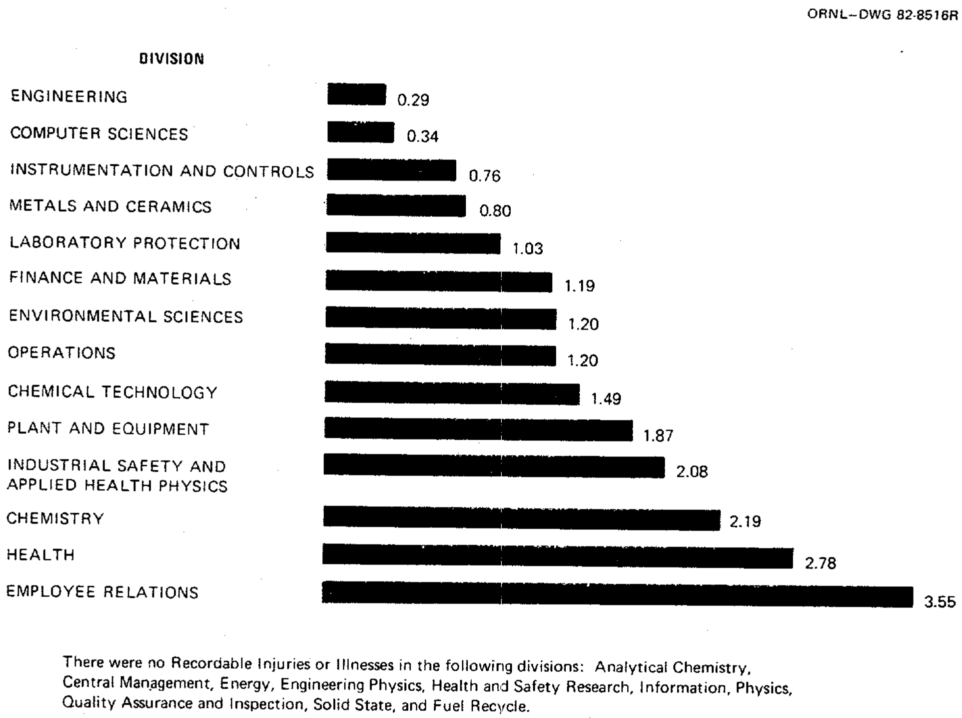

Fig. 5.1. Incidence rates of recordable injuries and illnesses for 1981, by division.

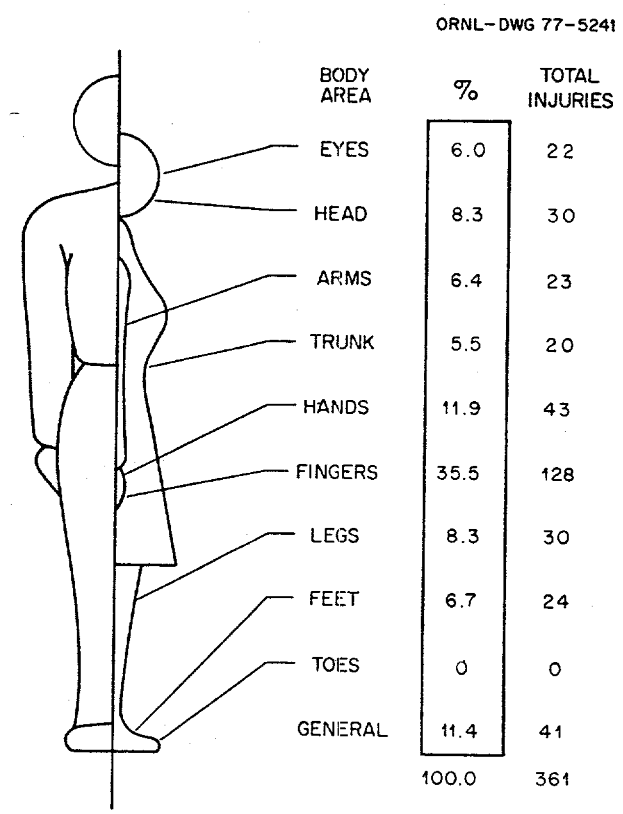

Fig. 5.2. Part of body injured.

Table 5.3. Summary of medical treatment cases at ORNL,[a] January 1, 1981–December 31, 1981

	First aid	Recordable injury or illness	Total
Number of injuries	320	41	361
Accident type			
Strike against	115	10	361
Struck by	60	12	
Falls	22	10	
Slip or twist	53	2	
Temperature	11	0	
Chemical	20	1	
Insect sting	12	0	
Caught in, on, or between	22	6	
Other	5	0	
Nature of injury			361
Abrasion, laceration, or puncture	135	20	
Burn (temperature)	14	0	
Burn (chemical)	7	0	
Contusion	57	1	
Insect sting	12	0	
Fracture or dislocation	1	13	
Strain or sprain	62	6	
Conjunctival (eye)	19	0	
Foreign body	8	1	
Other	5	0	
Part of body			361
Eye	22	0	
Foot or ankle	17	7	
Finger	110	18	
Hands	40	3	
Arms	21	2	
Head	25	5	
Leg	29	1	
Back	30	2	
Trunk	17	3	
Multiple parts	7	0	
Other	2	0	
Agent			41
Machine		3	
Materials		10	
Glass		2	
Sheet metal, steel, etc.		7	
Hand tools		8	
Nails, screws, wire, etc.		0	
Containers		0	
Chemical		1	
Vehicle		2	
Office furniture		3	
Unclassified		5	
Causitive factor			
Personal			
Unsafe attitude		28	
Inadequate training		1	
Bodily defects		0	
No unsafe personal factor		0	

Table 5.3 (continued)

	First aid	Recordable injury or illness	Total
Condition			
Improper safeguards		1	
Defective agent		5	
Hazardous arrangement		3	
Illumination		0	
Unsafe apparel		0	
No unsafe condition		3	
Unclassified		0	
Action			
Failure to use safe attire		1	
Operating or working at unsafe speed		6	
Using unsafe equipment		13	
No unsafe action		0	
Unsafe loading, mixing, or placing		0	
Taking unsafe position		0	

[a]All injury incidence rate = 8.38.

Periods for which no disabling injuries occurred are listed in Table 5.4. From May 11, 1980, through December 31, 1981, the Laboratory accumulated over 14 million work-hours without a disabling injury (lost-work-day case). Table 5.5 presents data on ORNL off-the-job disabling injuries and frequency rates for 1972–1981, and Table 5.6 compares these same statistics for the four UCC-ND installations for 1981.

Table 5.4. Disabling-injury-accident-free periods at ORNL, 1972–1981

	Employee-hours accumulated
Dec. 12. 1972–Apr. 25, 1973	2,327,051
Apr. 27, 1973–July 29, 1973	1,428,975
July 31, 1973–Jan. 15, 1974	2,760,549
Jan. 17, 1974–May 6, 1974	1,869,338
May 8, 1974–June 15, 1974	661,399
June 17, 1974–Aug. 11, 1974	926,437
Aug. 13, 1974–Dec. 5, 1974	2,010,547
Dec. 7, 1974–Apr. 6, 1975	2,570,994
Apr. 8, 1975–Nov. 10, 1975	4,543,462
Nov. 12, 1975–Sept. 15, 1976	6,375,994
Sept. 17, 1976–Apr. 24, 1977	4,588,847
Apr. 26, 1977–Jan. 14, 1978	5,830,521
Jan. 16, 1978–Sept. 26, 1978	6,041,210
Sept. 27, 1978–Mar. 23, 1979	3,826,579
Mar. 26, 1979–Sept. 14, 1979	4,007,810
Sept. 17, 1979–Oct. 24, 1979	1,096,371
May 10, 1980–Dec. 31, 1981	14,015,826
Best previous accident-free period	
July 4, 1968–Aug. 20, 1969	8,529,750

Table 5.5. Off-the-job disabling injuries and frequency rates for ORNL, 1972–1981

	Number	Days lost	Frequency
1972	17	990	1.25
1973	13	612	1.01
1974	35	1197	2.54
1975	36	1724	2.33
1976	46	1251	2.91
1977	34	765	1.98
1978	71	1055	3.95
1979	72	1499	4.00
1980	63	992	3.44
1981	60	834	3.29

Table 5.6. Comparison of off-the-job disabling injuries and frequency rates for the four UCC-ND installations, 1981

	Number	Frequency	Days lost
ORNL	60	3.29	834
ORGDP	60	2.88	1459
Y-12	74	2.88	2142
PGDP	23	3.48	753

Table 5.7 gives data for motor vehicle accidents for 1971–1981. Table 5.8 compares on-the-job disabling injuries for the four UCC-ND installations, and Table 5.9 compares RIIs for these installations.

Table 5.7. Motor vehicle accident statistics for ORNL, 1971–1981

	Number of vehicle accidents	Total damage ($)	Frequency rate[a]
1971	15	3595	7.66
1972	12	4641	5.93
1973	10	915	5.22
1974	15	1968	8.14
1975	7	2567	3.33
1976	14	5136	6.42
1977	12	8488	5.05
1978	29	9009	13.49
1979	17	4612	8.39
1980	6	3570	3.31
1981	8	3320	4.01

[a]Frequency rate = number of accidents per million miles driven.

Table 5.8. Comparison of on-the-job disabling injuries and frequency rates for the four UCC-ND installations, 1977–1981

	1977		1978		1979[a]		1980[a]		1981[a]	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
ORNL	1	0.12	3	0.36	3	0.07	2	0.05	0	0.00
Y-12	2	0.18	3	0.26	2	0.03	1	0.02	2	0.03
ORGDP	4	0.34	5	0.43	0	0.00	2	0.04	1	0.02
PGDP	3	0.65	1	0.22	1	0.05	2	0.11	0	0.00

[a] Lost-work-day cases and incidence rate.

Table 5.9. Comparison of recordable injuries and illnesses and incidence rates for the four UCC-ND installations, 1977–1981

	1977		1978		1979		1980		1981	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
ORNL	64	1.60	59	1.40	44	1.05	41	0.96	41	0.95
Y-12	79	1.39	75	1.29	56	0.91	80	1.25	53	0.86
ORGDP	134	2.26	82	1.40	72	1.25	55	0.98	49	0.96
PGDP	60	2.60	46	2.05	36	1.75	25	1.34	19	1.19

5.2 OFFICE OF OPERATIONAL SAFETY

The Office of Operational Safety (OOS) serves as the focal point for the operational safety activities (including reactor and criticality safety) of ORNL and provides liaison among ORNL, the UCC-ND Health, Safety, and Environmental Affairs Office, and the Department of Energy—Oak Ridge Operations (DOE-ORO) on operational safety matters. A primary responsibility of the office is coordinating and monitoring the activities of the Division Safety Officers (DSOs) and Radiation Control Officers (RCOs) and the Laboratory Director's Review Committees and ensuring follow-up of committee recommendations. The staff of the office also participates in a wide variety of operational safety matters, including radiation safety and development of safety policies, procedures, practices, and guidelines for various Laboratory operations. Through review and approval functions, the office provides assurance to management that Laboratory safety requirements are included in the design, modification, and construction of facilities and that all facilities, including reactors, are operated safely in accordance with ORNL and DOE requirements. The director of the office serves as the Laboratory's safety documentation and review coordinator, in accordance with Standard Practice Procedure D-5-29. In fulfilling this responsibility, the director and office staff provide coordination, direction, and approval of safety documentation to ensure compliance with Laboratory and DOE requirements. The office also provides coordination of safety activities in the decontamination and decommissioning (D&D) program to ensure that all environmental, safety, and health physics concerns are included.

5.2.1 Laboratory Director's Review Committees

The OOS staff continued to coordinate the activities of the Laboratory Director's Review Committees during 1981. The Laboratory has eight standing committees whose work OOS coordinates. These committees are responsible for reviewing and recommending steps for operations where significant or unique hazards exist.

In the coordinating role, the staff of the OOS is responsible for scheduling committee reviews, participating in reviews as ex-offico members of the committee, finalizing reports, documenting the reviews, and making certain that recommendations formulated as a result of the reviews are either implemented or resolved in a manner satisfactory to management. The 1981 activities of the various review committees are shown in Table 5.10. The practice of holding annual meetings at which review committees and ORNL's Executive Director met to discuss committee work for the year and to raise issues not covered in formal committee reports was started in 1979. This practice was deferred from this year to next because of the appointment of K. W. Sommerfeld as Executive Director late in 1981.

5.2.2 Implementation of DOE Manual Chapter 0531 and DOE Order 5481.1 Requirements

Enactment of DOE Manual Chapter 0531 (ref. 2) and, subsequently, DOE Order 5481.1 and the impending revision, 5481.1A (*Safety Analysis and Review System*), significantly influenced documentation requirements for facilities identified as nonreactor facilities. This manual chapter and order specify requirements of Safety Assessments (SAs), Preliminary Safety Analysis Reports (PSARs), Final Safety Analysis Reports (FSARs), and Operations Safety Requirements (OSRs) for all such facilities. (PSARs are required for new or major modified facilities only.) These documents must be developed in sequence with various stages of completion of a facility or project so that upon completion of construction or commencement of a project, the documentation requirements are also completed. It also requires that documentation supporting the safe operation of existing facilities be produced or revised to conform to specific requirements and format.

DOE Order 5841.1 expands safety documentation requirements to operations having hazards of a type and magnitude not routinely encountered or accepted by the public.

Although there were few new facilities or projects requiring such documentation, there are numerous existing nonreactor nuclear facilities for which the required documents have not been completed. During 1978, 33 existing facilities were in this category. A schedule of implementation of the Manual Chapter 0531 document requirements[2] for these existing facilities (modified to include 28 facilities) was developed in 1979 and was shown in Table 7.2.1 in ref. 3. The schedule will be revised as necessary to include any additional facilities requiring documentation in accordance with DOE Order 5481.1.

During 1981 safety analysis documentation continued on the 7920 Transuranium Processing Plant (TRU), 3019 Pilot Plant, 3100 Vault, a site-generic document, Solid Waste Storage Facility, 7025 Tritium Target Facility, and 5505 Transuranium Research Laboratory (TRL). In addition, five other existing facilities were added to the documentation schedule for FY 1981. These facilities were the 86-in. Cyclotron; the Alpha Labs, Room 136, Building 4508; the High Level Analytical Laboratory, Building 2026; the Alpha Isolation Lab, Building 3508; and the Radiation Gas Handling Building, 3033W. The schedule required all documents to be completed by midyear. However, the scheduled completion dates were not met, and although most document drafts were completed and sent to DOE-ORO

2. *DOE Manual Chapter 0531, Safety of Nonreactor Nuclear Facilities.*

3. J. A. Auxier et al., *Industrial Safety and Applied Health Physics Annual Report for 1979*, ORNL-5663 (September 1980).

Table 5.10. Summary of meetings held in 1981 by Laboratory Director's Review Committees[a]

Office of Operational Safety

Meeting dates	Subject	Documentation	Date submitted to DOE
	Radioactive Operations Committee reviews (ROC)		
Mar. 3	High-Level Examination Laboratory, Bldg. 3525	*b*	Apr. 16, 1981
Mar. 26	Radioactive Materials Analytical Laboratory, Bldg. 2026	*b*	Sept. 18, 1981
Apr. 28	Alpha Handling Facility, Bldg. 3038	*b*	Sept. 18. 1981
June 18	Isotope Research Materials Laboratory, Bldg. 3033 Annex	*b*	Sept. 18, 1981
July 2	Metal Recovery Facility, Bldg. 3505	*b*	Sept. 18. 1981
July 2	Fission Products Development Laboratory, Bldg. 3517	*b*	Sept. 18, 1981
Sept. 21	Physical Examination Hot Cells, Bldg. 3025	*b*	Dec. 1, 1981
Oct. 8	High Radiation Level Analytical Facility, Bldg. 3019-B	*b*	With this report
Nov. 19	Tritium Target Fabrication Facility, Bldg. 7025	*b*	With this report
	ROC Subcommittee activities associated with the Safety Documentation Program for Review of SARs and OSRs		
Feb. 12	Transuranium Research Laboratory SAR Draft, Bldg. 5505		
Apr. 13	Building 3033 SAR Draft		
Apr. 21, 23	705 Tritium Target Facility SAR Draft		
May 27	Solid Waste Storage Area SAR and OSR Drafts		
June 5	TRU Facility (7920) SAR Draft		
June 23	3019 Pilot Plant and 3100 Storage Vault OSR Drafts		
June 24	3033 OSR Draft		
Aug. 11	Building 4508 SAR and OSR Drafts		
Aug. 11	Gunite Tank Drilling Operation		
Aug. 13	3019 OSR		
Aug. 24	3508 SAR and OSR Drafts		
Sept. 17	Building 7920 (TRU) OSR Draft		
Dec. 14	Preoperational review of Bldg. 3027 fissile materials storage vault (to be completed in CY 1982)		
Dec. 18	New Hydrofracture Facility SAR Draft		
	Accelerators and Radiation Sources Review Committee (ARSRC)		
Feb. 23	Review of the 5 MV Van de Graaff and AN-400 Accelerators at Building 5500	*b*	July 22, 1981
June 25	Preoperational Review of the MFE Deuteron Accelerator in Building 6010	*b*	Sept. 18. 1981
Sept. 16	Accelerators and Radiation Sources Review Committee Review of Solid State Division's Van de Graaff Accelerators in Bulding 3003	*b*	With this report

Table 5.10 (continued)

Meeting dates	Subject	Documentation	Date submitted to DOE
Sept. 16	Accelerators and Radiation Sources Review Committee Review of the 14 MeV Neutron Generator in 2011	*b*	Dec. 1, 1981
Dec. 18	Accelerators and Radiation Sources Review Committee Review of ORIC and UNISOR	To be written	
December	Accelerators and Radiation Sources Review Committee Review of Source Group B	*b*	With this report
Fall 1981	Review of ORNL Accelerators for Compliance with ANSI N43.1-1978	Report to be transmitted to ORO by ORNL management	
	ARSRC activities associated with the Safety Documentation for review of SARs and OSRs		
Apr. 28 and continuing throughout 1981	Preoperational Review of the HHIRF and HHIRF SARs and OSRs		
June 30	Review 86-in. Cyclotron SAR and OSR Drafts		
	Reactor Operations Review Committee (RORC)		
Jan. 7 and Mar. 11	1980 review of Health Physics Research Reactor	*b*	Apr. 16, 1981
Jan. 20	1980 review of Bulk Shielding Reactor (BSR)	*b*	Apr. 16, 1981
Jan. 15 and 21 and Feb. 4	1980 review of Tower Shielding Facility (TSF)	*b*	July 22, 1981
Feb. 24	1980 review of Oak Ridge Research Reactor (ORR)	*b*	July 22, 1981
Mar. 3 and 16	1980 review of High Flux Isotope Reactor (HFIR)	*b*	July 22, 1981
Apr. 14, Aug. 15, and Sept. 17	Review of reactor operator training	Internal memo to C. C. Hopkins from RORC, Oct. 13, 1981	
May 1	New BSR servo system		
July 20	HFIR loss of control-plate screw heads		
December	Investigation of HFIR capsule exposure		
December	Review and approval of ORR, BSR, and TSR technical specifications	Internal memo to R. V. McCord from S. J. Ball, Dec. 21, 1981	
October	Reactor primary coolant makeup monitoring (ORR siphon-break system, change memo ORR-121)	Internal memo to G. H. Burger from S. J. Ball, Oct. 27, 1981	
Nov. 6 and 19	Meetings on 1981 HFIR review		
Nov. 25	Meeting on 1981 TSR review		

Table 5.10 (continued)

Meeting dates	Subject	Documentation	Date submitted to DOE
	Electrical Safety Committee		
Feb. 24 and Mar. 17	Discuss plans for 1981 activities		
Apr. 29	Conduct review of Metals and Ceramics Division		
June 18	Oak Ridge Electron Linear Accelerator electrical safety review	*b*	Dec. 1, 1981
Aug. 25	Conducted preliminary electrical safety review of Instrumentation and Controls Division		
	Transportation Committee		
Oct. 6	Overall ORNL Transportation Program	Internal memo to K. W. Sommerfeld from Transportation Committee, Nov. 21, 1981	
October	Approval of model DG-1 tritium shipping container	Internal memo to C. C. Hopkins from Transportation Committee, Oct. 28, 1981	
	Criticality Committee		
Sept. 28	Reinstatement of NSR 715-R2		
	Discuss 1981 activities and annual audit		
	Discuss 1982 plans		
Nov. 9	Approve new NSR for 3027 Vault and discuss new fissle material limits at the solid waste storage area		
Dec. 15	First meetings of the 1981 audit (3019 NSRs)		
	1980 Nuclear Safety Annual Audit	*b*	Apr. 16, 1981
	High Pressure Equipment Review Committee (HPERC)		
Mar. 3	Meeting concerning High Pressure Seminar		
Mar. 13	High-pressure, high-temperature system, BG-72, Bldg. 4501	Internal memo, Mar. 18, 1981	
Nov. 23	Autoclave installation, Bldg. 3592	Internal memo, Dec. 3, 1981	
	Reactor Experiments Review Committee (RERC)		
Jan. 14	High-uranium fuel element development experiment in ORR		
Jan. 22 and Feb. 5	HFIR magnetic fusion energy (MFE) T-1 and T-2	Internal memo to G. H. Jenks to C. C. Hopkins, Feb. 24, 1981	

Mar. 12	ORR experiments	
June 30	Experiment OC-1	
Oct. 9	Engineering Technology and Metals and Ceramics experiment HFIR-MFE-RB1, 2, 3	Memo from G. H. Jenks to C. C. Hopkins, Oct. 20, 1981
Dec. 15	Proposed changes to MFE 4A experiment in ORR	Memo from G. H. Jenks to K. W. Sommerfeld, Dec. 29, 1981

[a]This summary is not intended to be inclusive; additional informal, undocumented meetings were conducted during 1981.
[b]Documentation provided in ORNL central file reports (internal distribution only).

for review in CY 1981, they were not completed during the fiscal year. The status of document preparation at the end of CY 1981 was as follows: ten SARs and seven OSRs were sent to DOE-ORO for review and approval; one SAR and one OSR for the 86-in. Cyclotron at Y-12 were approved; and one SAR and three OSRS were not completed. A total of $344,600 was spent on document preparation. Because the documents were not completed in FY 1981, it was necessary to allocate additional funds to complete them in FY 1982. The cost schedule for completion of these documents in FY 1982 ($110,000) is shown in Table 5.11, along with the schedule for additional facilities added for the first time: operations in Buildings 3028, 3038, and 3033 Annex. Safety documentation costs for these added facilities were estimated to be $200,000, giving a total expenditure for all documentation preparation in FY 1982 of $310,000.

In addition to safety documents for existing facilities, documents for several new facilities and projects were prepared. SARs and OSRs for the new storage vault (Building 3027) and the Holifield Heavy Ion Facility were completed and sent to DOE for review and approval. In addition, documents for the Gunite Tank Project and the New Hydrofracture Facility were being prepared by Engineering, with assistance from the operating groups. Completion, including DOE-ORO approval of all these documents, is expected in early 1982. In fact, the 3027 Vault documents have just recently been approved by DOE.

5.2.3 Division Safety Officers' and Radiation Control Officers' Activities

Operating and research divisions at the Laboratory have appointed Division Safety Officers and Radiation Control Officers (DSOs and RCOs) for coordinating safety and radiation safety, respectively, within their divisions. Table 5.12 is a current list of DSOs and RCOs and the divisions they represent.

The OOS conducts quarterly meetings to disseminate information of interest and importance to DSOs and RCOs. During 1981 the meetings were conducted on January 20, April 14, July 23, and October 8; they were documented in minutes maintained in ORNL's Central File. The OOS reviews and comments on safety analysis reports, project safety summaries, safety inspections, and reports of accidents submitted by DSOs and RCOs. It also reviews operations for recommendation and approval, the requirements of which are not specifically covered in manuals.

5.2.4 Staff Consultation, Review, and Other Activities

To ensure continued safe operation of Laboratory facilities, the OOS engages in activities in addition to those previously described.

OOS staff consulted with numerous operating facility staff members and performed reviews and audits of both routine and requested operations and facilities. Numerous requests were received for approval of proposed experiments or operations, including disposal of radioactive wastes, handling and processing special radioactive materials, and transportation of nuclear materials.

Other staff activities included participating in all accident or near-miss investigations and assisting with or observing performance of emergency drills. Considerable effort went into the planning, execution, and critique of an extensive criticality drill held at the new Building 3027 Storage Vault. The staff also participates in and develops procedures for the *Health Physics Manuals* and *ORNL Safety Manuals*.

Assistance was given to several groups in the design and procurement of glove boxes and to Engineering staff in establishing criteria for polycarbonate glove-box windows. Additionally, the staff

Table 5.11. Safety documentation preparation and cost schedule, FY 1982

$310,000 total FY 1982 scheduled cost

Facility and division	SAR Draft to OOS	SAR Draft to DOE	OSR Draft to OOS	OSR Draft to DOE	FY 1982 cost scheduled ($)
TRL, 5505[a] (Chemistry)	Complete	Apr. 1981[b]	Apr.1982	July 1982	10,000
3033 W. radiation-gas handling[c] (Operations)	Complete	June 1981[b]	Complete	Aug. 1981[b]	10,000
Site-generic document[a] (Operations)	Complete	May 1981[b]	NA[d]	NA	5,000
7025 Tritium Target Facility[a] (Operations)	Complete	July 1981[b]	Jan. 1982	May 1982	10,000
86-in. Cyclotron[b] (Operations)	Complete	Approved	Complete	Approved	5,000
Solid waste storage[a] (Operations)	Complete	Sept. 1981[b]	Complete	Dec. 1981[b]	10,000
4508, Rm. 136, Alpha Labs[c] (Metals and Ceramics)	Complete	Oct. 1981[b]	Complete	Oct. 1981[b]	10,000
2026 High Level Analytical Lab[c] (Analytical Chemistry)	Jan. 1982	May 1982	Nov. 1981	May 1982	10,000
3508 Alpha Isolation Lab[c] (Chemical Technology)	Complete	Oct. 1981[b]	Complete	Oct. 1981[b]	10,000
TRU 7920[a] (Chemical Technology)	Complete	Aug. 1981[b]	Complete	Dec. 1981[b]	20,000
3019 Pilot Plant[a] (Chemical Technology)	Complete	May 1981[b]	Complete	Nov. 1981[b]	10,000
3028 Short Lived Fission Product Development Laboratory [to be done in conjunction with Source Fabrication Facility (Operations)]	July	Sept.	July	Sept.	55,000
3038 Facility (includes all operations in building: alpha handling, packaging, IRML,[e] and other) (Operations)	July	Sept.	July	Sept.	90,000
3033 Annex IRML[e] (Operations)	July	Sept.	July	Sept.	55,000

[a]Started in FY 1980; listed cost is for completion in FY 1982.
[b]Already transmitted to DOE; DOE comments to be incorporated and document issued in FY 1982.
[c]Started in FY 1981; scheduled cost is for completion in FY 1982.
[d]NA = not applicable.
[e]Isotopes Research Materials Laboratory.

Table 5.12 Division Safety Officers and Radiation Control Officers

Division	Name
Analytical Chemistry	J. C. Price, RCO
	J. S. Wike, DSO
Biology	J. A. Otten, DSO, RCO
Chemical Technology	C. D. Watson, DSO, RCO
	F. A. Kappelmann, Alternate
Chemistry	C. E. Haynes, DSO, RCO
	W. D. Carden, Alternate
Computer Sciences	J. M. Barnes, DSO, RCO
Central Management	
Employee Relations	J. A. Holloway, Jr., DSO
Energy	C. M. Haaland, DSO, RCO
Engineering	H. D. MacNary, DSO, RCO
Engineering Technology	C. A. Mills, DSO
	R. B. Gallaher, Associate DSO
	A. W. Longest, RCO
Engineering Physics and ORELA	Z. W. Bell, DSO, RCO
	S. L. Rider, Alternate
Environmental Sciences	M. H. Shanks, DSO, RCO
Finante and Materials	G. E. Testerman, DSO
Fuel Recycle	D. E. Dunning, DSO, RCO
Fusion	R. S. Edwards, DSO, RCO
Health	J. A. Ealy, DSO, RCO
	W. E. Porter, Alternate
Health and Safety Research	J. A. Roberts, DSO, RCO
Industrial Safety and Applied Health Physics	R. E. Millspaugh, DSO
	A. J. Smith, RCO
Information	E. J. Howard, Sr., DSO, RCO
	A. J. Shelton, DSO, RCO
Instrumentation and Controls	E. M. Robinson, DSO, RCO
Laboratory Protection	R. L. Atchley, DSO
	H. C. Austin, RCO
Metals and Ceramics	W. H. Miller, Jr., DSO, RCO
	R. W. Knight, Alternate
	E. S. Bomar, Associate RCO
MIT School Engineering Practice	W. W. Doerr, DSO, RCO
Operations	S. J. Rimshaw, DSO, RCO
Physics	R. L. Auble, DSO, RCO
Plant and Equipment	R. H. Winget, DSO, RCO
Quality Assurance and Inspection	J. L. Holbrook, DSO, RCO
	R. G. Pope, Alternate
Solid State	R. R. Coltman, DSO
	H. R. Child, RCO

assisted in reviewing D&D criteria and determining appropriate site boundaries for safety analysis documentation, proposed Laboratory facility siting, and seismic and wind criteria for the ORNL area. Additional assistance was provided to the D&D program in planning and carrying out radiological characterization for Building 3505 and planning D&D activities for removal of old intermediate-level waste (ILW) lines, upgrading the stack system in Building 3039, and decontaminating the curium cells in Building 3028.

Considerable staff effort was put forward in participating in and answering questions raised during the review of the Oak Ridge Research Reactor (ORR) and the Bulk Shielding Reactor (BSR) by the DOE Headquarters Nuclear Facility Personnel Qualification and Training Committee (NFPQT). This review was an extension of the previous review of the High Flux Isotope Reactor (HFIR).

As part of the responsibility for providing liaison between management and DOE on safety matters, many meetings were held with DOE-ORO safety staff. These included participation in the following:

1. DOE Industrial and Construction Safety Audit—September 28 and 29 and October 5–7 and 13, 1981;
2. DOE Nuclear and Criticality and Transportation Safety Audit—August 31–September 4, 1981;
3. DOE Headquarters Safety Assessment of the ORR and BSR—September 8–11, 1981;
4. DOE Environmental Management Appraisal—October 27–29, 1981;
5. DOE Annual Health Physics Appraisal—December 1980–January 1981;
6. DOE 1980 Reactor Safety Appraisal—completed March 1981;
7. DOE 1981 Reactor Safety Appraisal—not complete at this date; and
8. DOE Nuclear Facility Safety Appraisal (Manual Chapter 0531)—April 22, 1981.

OOS responsibilities in audits also include ensuring follow-up of audit recommendations and providing implementation progress reports when required.

The OOS also participated in the UCC-ND Safety and Health Audit of ORNL, which included audits of industrial and operational safety, industrial hygiene, and the Laboratory's safety documentation program, required by DOE Order 5481.1 and Standard Practice Procedure D-5-29.

5.2.5 Summary

No facility or nuclear reactor accidents or incidents of an operational nature that resulted in injury to personnel or that were reportable to DOE other than as unusual occurrence or quality assurance (QA) deficiency reports occurred in 1981.

OOS continued to review operations and facilities by appropriate Director's committees to ensure management of continued safe operation of all Laboratory facilities. Work continued on implementation of Manual Chapter 0531 and DOE Order 5481.1; funds were allocated and schedules and programs for completion of safety analysis reports for existing facilities were revised. A greater effort in the development of D&D criteria continued, along with additional support in planning and carrying out radiological characterization and actual D&D work on selected facilities.

6. Presentation of Research Results

6.1 PUBLICATIONS

M. T. Ryan, "A Summary of the Radiological Impacts of Uranium Recovery in the Phosphate Industry," *Nucl. Saf.* **22**(1), 70–77 (January–February 1981).

M. W. Knazovich, "How To Survive A Hotel Fire," *Lab News*, p. 5 (February 1981).

T. W. Oakes, M. A. Montford, K. E. Shank, E. B. Wagner, T. G. Scott, and J. S. Eldridge, *Methods and Procedures Utilized in Environmental Management Activities at Oak Ridge National Laboratory*, ORNL/TM-7212 (March 1981).

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6.2 PRESENTATIONS AND LECTURES

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T. W. Oakes, "Radioactivity in Coal," Environmental Engineering Seminar, University of Tennessee, Knoxville, Tenn., Feb. 10, 1981.

T. W. Oakes, "Environmental Monitoring—A Review," ORAU-NRC Health Physics and Radiation Protection Course, Feb. 24, 1981.

T. W. Oakes, "Water Monitoring," ORAU-NRC Health Physics and Radiation Protection Course, Feb. 25, 1981.

T. W. Oakes, "Quality Assurance in Environmental Monitoring," ORAU-NRC Health Physics and Radiation Protection Course, Feb. 27, 1981.

T. W. Oakes, "Environmental Monitoring at ORNL," ORAU-NRC Health Physics and Radiation Protection Course, Feb. 30, 1981.

M. F. Fair, "Health Physics," a one-week course presented to the Department of Environmental Management, February 1981.

R. E. Millspaugh, "Safety for Supervisors," Supervisors Development Program, Plant and Equipment Division Supervisors, February 1981.

C. D. Berger, "Lung Counting," ORAU Training Program, Mar. 6, 1981.

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H. W. Dickson, "Status of Personnel Dosimetry for Mixed Field Radiation," Atlanta Chapter of Health Physics Society, Atlanta, Ga., Mar. 12, 1981.

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J. A. Auxier, "Low Level Effects of Radiation on Humans," ORAU Traveling Lecture, Grambling State University, Monroe, La., Mar. 19, 1981.

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C. D. Berger, "Whole Body Counting," ORAU Training Program, Mar. 30, 1981.

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C. E. Haynes, "Transuranium Element Health Physics," ORAU-NRC Health Physics and Radiation Protection Course, April 1981.

C. H. Miller, "Protective Clothing," ORAU-NRC Health Physics and Radiation Protection Course, April 1981 and October 1981.

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M. W. Knazovich, "Interaction Management," IS&AHP Division Supervisors, ORNL, May–June 1981.

J. A. Auxier, "Health Effects of Low Level Radiation," American Nuclear Society Annual Meeting, Miami Beach, Fla., June 8, 1981.

C. D. Berger, Training Film (Videotape), "Internal Dosimetry," Y-12 Plant, June 9, 1981.

T. W. Oakes, "Environmental Monitoring," a five-week Health Physics Course presented at ORAU, June 9, 1981.

C. D. Berger, "Whole Body Counting," ORAU Training Program, June 10, 1981.

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C. D. Berger, "Whole Body Counting," ORAU Training Program, Sept. 16, 1981.

C. D. Berger, "Bioassay," REAC/TS Training Program, ORAU, Sept. 17, 1981.

T. W. Oakes, "Federal and State Compliance Requirements" (Keynote Address), Symposium on the Management of Hazardous Wastes on Campus, ORAU, Sept. 17–18, 1981.

C. D. Berger, "Bioassay and Whole Body Counting," NRRPT Review Course, ORAU, Oct. 1, 1981.

C. D. Berger, "Special Detectors for Whole Body Counting," ORAU Training Course, Oct. 19, 1981.

B. M. Eisenhower, "A Management and Control Program for Hazardous Materials: A Starting Point," Symposium on the Management of Hazardous Wastes on Campus, ORAU, Sept. 17–18, 1981.

J. T. Blackmon, Jr., "A National Laboratory Management Model," Symposium on the Management of Hazardous Wastes on Campus, ORAU, Sept. 17–18, 1981.

J. A. Auxier, "Development of the Dosimetric Program, T-65 Values," DOE Symposium on Reevaluations of Dosimetric Factors, Hiroshima and Nagasaki, Sept. 18, 1981.

J. A. Auxier, "Radiation: What It Is, Where It Comes From, and How People Are Protected," Sigma Delta Chi Seminar on Radiation for Journalists, Las Vegas, Nev., Sept. 22, 1981.

H. W. Dickson, "Criticality Accidents," REAC/TS Course—Health Physics in Radiation Accidents, ORAU, Sept. 22, 1981.

D. R. Simpson and Juel F. Emery, "Radiological Assessment of the Decontamination and Decommissioning of a Small-Scale Fuel Reprocessing Plant," Twenty-fifth ORNL Conference on Analytical Chemistry in Energy Technology, Gatlinburg, Tenn., Oct. 6–8, 1981.

H. W. Dickson, "Nuclear Fission," National Registry of Radiation Protection Technicians' Certification Refresher Course, East Tennessee Chapter of Health Physics Society, Sept. 24, 1981.

J. R. Muir, "Personnel Monitoring," NRRPT Certification Course, ORAU, September 1981.

C. D. Berger, "The ORNL Whole Body Counter," ORNL Research Committee, Oct. 7, 1981.

L. C. Henley, "A Quantitative Radiochemical Technique for Collection and Determination of Very Low Levels of Actinide Elements by Anion Exchange," 27th Annual Bioassay, Analytical, and Environmental Chemistry Conference, Santa Fe, N.M., Oct. 7–8, 1981.

T. W. Oakes, "Acid Rain," Environmental Engineering Seminar, University of Tennessee, Knoxville, Tenn., Oct. 12, 1981.

J. A. Auxier, "Development of the Dosimetric Program, T-65 Values," Joint Chapter Meeting, Health Physics Society, Huntsville, Ala., Oct. 16, 1981.

G. H. Burger, "The Safety Program of the Oak Ridge National Laboratory—A Different Approach," National Safety Congress, Chicago, Ill., October 1981.

G. H. Burger, "Operational Readiness Review," DOE Nuclear Facility Safety Conference, Augusta, Ga., October 1981.

J. A. Auxier, "The Effects of Low Levels of Radiation on Humans," Third National and First International Congress of the National Association of Technicians of Medical Radiology, Panama City, Panama, Nov. 7, 1981.

T. W. Oakes, "Ozone," Environmental Engineering Seminar, University of Tennessee, Knoxville, Tenn., Nov. 30, 1981.

M. W. Knazovich, "Division and Departmental Safety Performance Rating System," DOE Safety Engineers Conference, Idaho Falls, Ida., November 1981.

T. W. Oakes, "Greenhouse Effects," Environmental Engineering Seminar, University of Tennessee, Knoxville, Tenn., Dec. 1, 1981.

C. D. Berger, "An Alpha-Beta-Gamma Spectrometer as an Aid in Directing Decontamination of Soils," ANS 1981 Winter Meeting, San Francisco, Calif., Dec. 2, 1981.

E. D. Gupton, "Personnel Monitoring for Beta Radiation at ORNL," Beta Radiation Workshop, DOE Environmental Monitoring Laboratory, New York, N.Y., Dec. 8, 1981.

M. T. Ryan, "Basic Health Physics Review," a course presented to the staff of the Radiation Monitoring Section of IS&AHP Division, December 1981.

C. E. Haynes, "Radiation Survey and Radiation Protection Orientation Program," ORNL Chemical Technology Division, December 1981.

M. T. Ryan, "The Marshall Island Dosimetry Program," ORNL seminar, November 1981.

6.3 IS&AHP LUNCHEON SEMINARS

"Vignettes of Early Radiation Workers," videotape, Feb. 15, 1981.

"A Discussion of the 1980 BEIR Report," videotape, Feb. 26, 1981.

"Measurement of the Kerma Ratio (K of Tissue Equivalent Plastic to K of Carbon) and Its Application to Neutron Therapy Beam Dosimetry, Kenneth Lewis, University of Illinois, Mar. 16, 1981.

"The Birds and the Bees," T. W. Oakes, May 15, 1981.

"If Japan Can, Why Can't We?" videotape, May 22, 1981.

"Marshall Islands—1981," Mike Ryan, Oct. 1, 1981.

"Meetings, Bloody Meetings," videotape, Oct. 13, 1981.

"The Annual UCC-ND Safety Award Luncheon," videotape, Oct. 30, 1981.

"Video Display Terminals," videotape, Nov. 3, 1981.

"Sun Tanning Booths," videotape, Nov. 3, 1981.

"The Use of RECON by the Health Physicist," W. A. Alexander, Dec. 3, 1981.

6.4 PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

J. F. Alexander, certification for Part I of the American Board of Health Physics Certification Examination; member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society.

W. A. Alexander, member, Health Physics Society; Area Representative, East Tennessee Chapter, Health Physics Society.

J. A. Auxier, consultant to Radiation Effects Research Foundation, Japan; member, Dose Assessment Steering Group, U.S. Department of Energy; advisor, U.S. Department of Justice on Health Physics and Radiation Dosimetry; member, National Academy of Sciences Panel on Hiroshima/Nagasaki Occupation Forces; member, Subcommittee on Exposure at Tests of Nuclear Weapons, National Academy of Sciences; member, National Council on Radiation Protection and Measurements; member, Health Physics Society; member, Awards Committee, Health Physics Society; member, East Tennessee Chapter, Health Physics Society; member, Ad Hoc Committee on Scientific and Public Issues, Health Physics Society; member, NCRP Scientific Committee 34 on Maximum Permissible Concentrations for Occupational and Non-Occupational Exposure; member, NCRP Scientific Committee 57 on Internal Emitter Standards; member, NCRP Scientific Committee 63 on Radiation Exposure Control in Peacetime and Wartime; member, The Safety Advisory Board for Three Mile Island Unit 2; member, National Academy of Sciences Committee on Emergency Management; member, Advisory Council, Institute of Nuclear Power Operations.

C. D. Berger, member, East Tennessee Chapter, Health Physics Society; Secretary, 1981–1982, East Tennessee Chapter, Health Physics Society.

J. T. Blackmon, Jr., member, Society of Fire Prevention Engineers; member, American Association for the Advancement of Science; member, National Fire Protection Association (NFPA); member, NFPA Furnace and Oven Code Committee; member, National Safety Council; chairman, Oak Ridge Building Code Appeals Board.

G. H. Burger, member, East Tennessee Chapter, Health Physics Society; member, American Nuclear Society; member, Instrument Society of America.

T. J. Burnett, member, American Industrial Hygiene Association; member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society.

H. M. Butler, member, Health Physics Society; chairman, Admissions Committee, Health Physics Society; member, East Tennessee Chapter, Health Physics Society; member, Advisory Committee on Nuclear Technology, Chattanooga State Community College; recertified by American Board of Health Physics; chairman, Nominations and Awards Committee, East Tennessee Chapter, Health Physics Society.

H. W. Dickson, member, Health Physics Society; Treasurer, Health Physics Society; member, East Tennessee Chapter, Health Physics Society; member, International Radiation Protection Association; member, Radiation Research Society.

D. T. Dice, member, American Nuclear Society Committee 15.14, Physical Security of Research Reactors; member, Health Physics Society.

B. M. Eisenhower, member, American Industrial Hygiene Association; member, East Tennessee Chapter, Health Physics Society; member, American Society of Safety Engineers; member, East Tennessee Chapter, American Society of Safety Engineers; Registered Environmentalist for State of Tennessee.

M. F. Fair, member, East Tennessee Chapter, Health Physics Society.

E. D. Gupton, recertified by American Board of Health Physics, July 1981; member, Health Physics Society; member, Sigma Pi Sigma, National Honorary Physics Society.

L. C. Henley, recertified by American Board of Health Physics, July 1981.

L. L. Huey, member, East Tennessee Chapter, American Society of Safety Engineers.

B. A. Kelly, member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society; member, Chi Epsilon (National Civil and Environmental Engineers Honor Society).

M. W. Knazovich, president, East Tennessee Chapter, American Society of Safety Engineers.

R. E. Millspaugh, member, East Tennessee Chapter, Health Physics Society.

J. R. Muir, member, Health Physics Society; chairman, Rules Committee, 1981–1982, Health Physics Society; member, East Tennessee Chapter, Health Physics Society Rules Committee; member, Association of Records Managers and Administrators.

T. W. Oakes, member, New York Academy of Science; member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society; Chairperson, WATTec Committee, East Tennessee Chapter, Health Physics Society; member, Public Information Committee, East Tennessee Chapter, Health Physics Society; member, American Industrial Hygiene Association (AIHA); member, Air Pollution Committee, AIHA; member, American Nuclear Society; member, American Association for the Advancement of Science; member, American Society of Professional Ecologists; member, Certified Hazardous Control Management Association.

W. F. Ohnesorge, member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society.

E. B. Wagner, member, Health Physics Society; member, East Tennessee Chapter, Health Physics Society.

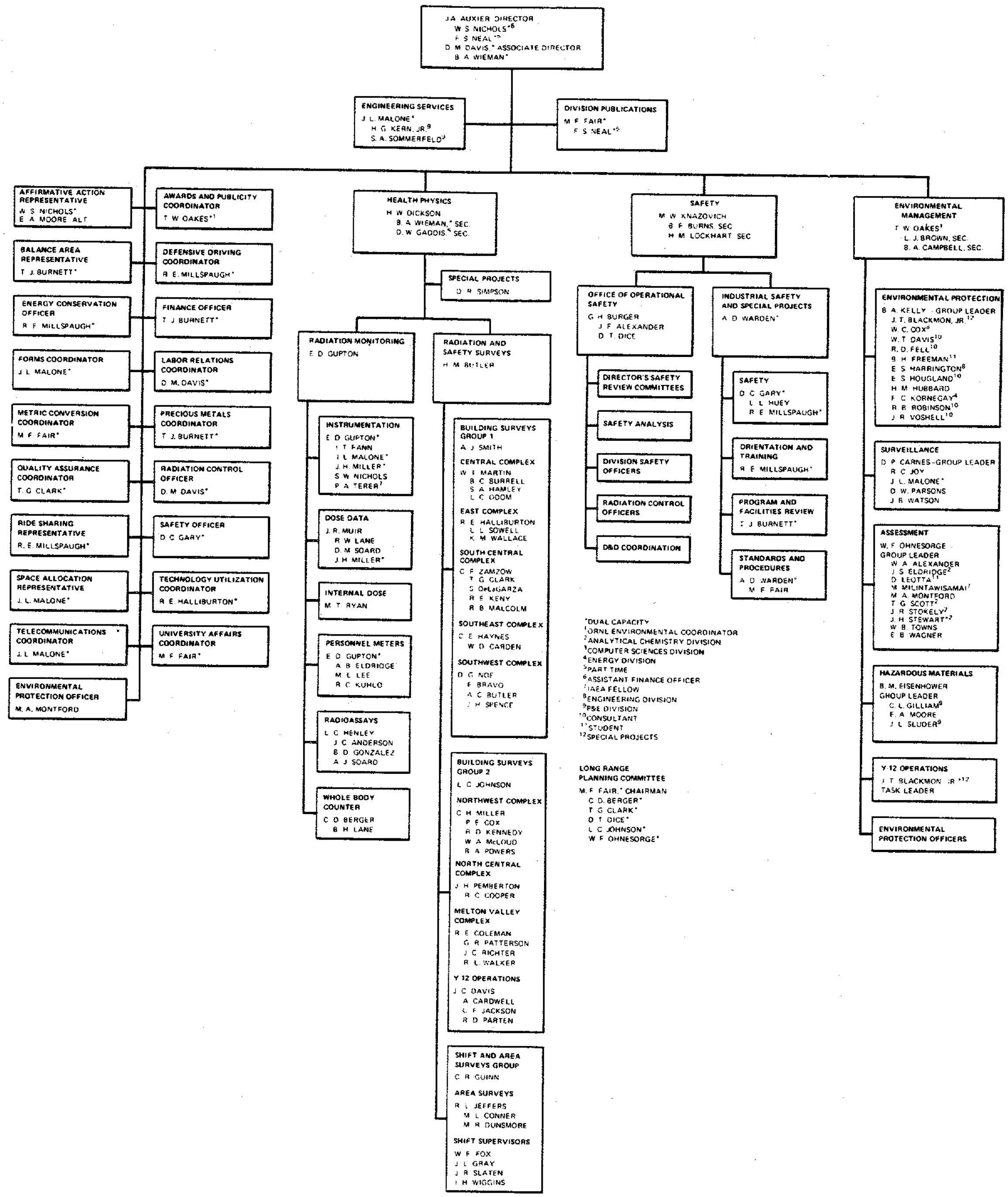
6.5 AWARDS

H. W. Dickson, 1981 Elda E. Anderson Award from the Health Physics Society.

J. T. Blackmon, Jr., 1981 Cameron Award from the National Safety Council.

INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS DIVISION

JULY 1 1981



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